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SUMMARY
OF
RESEARCH REPORT
8972

EARTH TEMPERATURE AND THERMAL DIFFUSIVITY AT SELECTED STATIONS IN THE UNITED STATES

by

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P. R. Achenbach

May 1965

This is a summary of a report which has been reviewed by the Office of Civil Defense and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Office of Civil Defense.

Contract No. OCD-OS-62-44, Subtask 1211A

National Bureau of Standards
Building Research Division
Washington, D.C.

Summary prepared by
National Bureau of Standards
June 1965

The National Bureau of Standards had investigated thermal environment of a family shelter for various test conditions experimentally and has been developing analytical and numerical computational programs that predict the thermal performance of occupied underground shelters. Details of these programs have been reported previously. The numerical program was designed to predict, by a digital computer, temperature and humidity in underground shelters for simulated occupancy conditions, of any size, shape and construction detail for any combination of properties of the surrounding soil, outdoor weather conditions, number, activity and density of occupants, and type of cooling and ventilating facilities. The thermal performances of several prototype shelters with simulated occupants of several different sizes have been adequately simulated by the present computer program. The computer program is basically capable of predicting thermal environment of many different underground structures if input parameters are accurately known, such as was the case for the prototype shelters. Some of the important, yet not well defined, input parameters for underground thermal performance are temperature and properties of the earth surrounding the shelter, and conditions of outdoor air which is usually used for shelter ventilation. The earth temperature, earth properties and outdoor air conditions are interdependent near the earth's surface, and these parameters vary with time and from locality to locality throughout the United States. Thus, it was decided that the earth temperature data and outdoor weather data should be analyzed to establish reasonable computer input data for the purpose of predicting the shelter thermal

environment and to facilitate design of economical mechanical systems for underground shelters. This report covers the analysis of earth temperature data.

A total of 63 sets of monthly average earth temperature data, including some that had been already published and additional data obtained from the climatological data of the U.S. Weather Bureau, have been tabulated and analyzed in this report. This technique employs a simple harmonic heat transfer equation of earth temperature vs. time to calculate the earth temperatures from a few characteristics such as annual average temperature, surface temperature, annual temperature amplitude, thermal diffusivity, and surface temperature phase angle from a selected reference point. These characteristic values were analyzed using least-squares constant which were obtained by fitting a simple harmonic equation to the data of the monthly average earth temperatures. The higher harmonic terms in describing annual cycle of monthly average earth temperatures were neglected in this analysis.

By knowing the characteristics described above, earth temperature vs. depth may be calculated for various climatic regions and for various thermal properties. Simplified analytical studies on shelter heat transfer, however, require only an average earth temperature surrounding the shelter at the time of shelter entry instead of the detailed temperature distributions. The average earth temperatures from surface to 10-ft depth have also been calculated using these same earth temperature characteristics.

Findings

It was found during the analysis that the simplified heat conduction theory based upon a simple harmonic presentation of earth temperatures provided a fair approximation of monthly average earth temperature except near the surface, provided the annual average temperature, the annual amplitude and phase angle of the surface temperature, and the thermal diffusivity are known.

In-situ thermal diffusivities of earth were computed from the observed earth temperature data both by amplitude method and phase angle method. The diffusivities computed by these two methods for each of earth temperature stations showed reasonably good agreement for most of the stations. Moreover, most of the diffusivity values were in the range from 0.015 and 0.035 ft^2/hr. The difference in the thermal diffusivities calculated by the two methods could not be attributed definitely to known causes. The annual averages of monthly average earth temperature, as expected, were very close to the annual average outdoor air temperature and to the Collins' ground water temperature of a given location. The annual amplitude of the monthly average earth surface temperature, however, did not show a good correlation to the annual amplitude of monthly average outdoor air temperature. The phase angle measured from January 1st for monthly average earth temperatures and air temperatures were also compared. While the phase angle values of air temperature cycle showed a consistent value of approximately 0.6 radian (5 weeks), the earth surface temperature phase angles ranged from 0.4 radian and 0.8 radian (3.3 to 6.7 weeks).

More extensive studies are necessary to establish a functional relation between earth surface temperature and outdoor air temperature for various types of soil, earth surface characteristics, and climatic conditions.

Although all available earth temperature data were compiled during this study, the stations were widely separated in most of the southern and western states. It is recommended, therefore, that data be obtained at additional stations in those regions during future studies.

NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT		NBS REPORT
42103-12-4210436	June 22, 1965	8972

Earth Temperature and Thermal Diffusivity at Selected Stations in the United States

By

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Prepared for the
Office of Civil Defense
U.S. Department of the Army

This report has been reviewed by the Office of Civil Defense and approved for issuance. Approval does not signify that the contents necessarily reflect the views and policies of the Office of Civil Defense.

Contract No. OCD-OS-62-44, Subtask 1211A

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

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NOMENCLATURE

Symbol		Unit
A	Annual average earth temperature: (Least-Squares Constant)	(°F)
B	Amplitude of the annual cycle of the monthly average earth temperature at a given point (Least-Squares Constant)	(°F)
BA (BA')	Amplitude of the monthly average air temperature	(°F)
BC	Projected earth surface temperature amplitude (B at x=o)	(°F)
C_n	Earth temperature amplitude of nth harmonic	(°F)
D	Thermal diffusivity of earth	(ft^2/hr)
D(B)	Thermal diffusivity of earth calculated by the amplitude method	(ft^2/hr)
D(P)	Thermal diffusivity of earth calculated by the phase lag method	(ft^2/hr)
e	Base of the natural logarithm	(dimensionless)
K	Index for identifying temperature data at a given time	(dimensionless)
L	Depth from the earth's surface	(ft)
log	Natural logarithm	
N	Index for denoting total number of temperature data at a given depth	(dimensionless)
n	Integer referring to nth harmonic of the Fourier series expression of temperature cycle	(dimensionless)
P	Phase angle of the earth temperature cycle for given x	(radian)
PA (PA')	Phase angle of the air temperature cycle	(radian)

Symbol		Unit
PO	Projected phase angle at the earth's surface (x=o)	(radian)
SD	Standard deviation of the observed earth temperatures from those calculated by the least-squares fit equation	(°F)
t	Calculated monthly average earth temperature	(°F)
t_K	Observed monthly average earth temperature	(°F)
t_L	Average earth temperature from surface to a depth L	(°F)
T	Period of the temperature cycle (= 8766 hrs)	
TA (TA')	Annual average air temperature	(°F)
TW	Ground water temperature	(°F)
x	Downward distance coordinate from the earth's surface	(ft)
α, α_1, α_2	Temperature functions	(°F)
δ_n	Temperature phase angle referring to the nth harmonic	(radian)
ξ_1, ξ_2, ξ_3, ξ_4, ξ_5	Trigonometric functions	(dimensionless)
ω	Angular velocity factor = $\frac{2\pi}{T}$	(radians/hr)
θ	Elapsed time from January 1st	(hr)
β	$\sqrt{\frac{\pi}{DT}}\,L$ · dimensionless depth	
ν	Phase angle for integrated depth average	(radian)
Γ	Dimensionless amplitude for integrated depth average	

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ABSTRACT

To provide information related to the heat transfer in underground installations, 63 sets of data showing annual variations of monthly average earth temperatures at various depths throughout the 48 contiguous states of the United States of America have been compiled and analyzed for the Office of Civil Defense. These data have been used to compute the annual average amplitude and phase angle of the earth temperature by a least-squares method. Thermal diffusivities of earth computed from the observed temperature data by both the amplitude method and phase lag method were compared for selected earth temperature stations. The monthly average earth temperature at depth intervals of two feet to a depth of 10 feet and the annual maximum and minimum integrated average temperatures in this region were calculated for each station for a selected value of thermal diffusivity using the results of the least-squares analysis. Annual average values of earth temperature and the amplitude and phase angle of the annual cycle of earth surface temperature were compared with the corresponding values of air and ground water temperatures.

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National Bureau of Standards

1. Introduction

Earth temperature is one of the most important parameters affecting heat transfer in underground installations. Recent studies of underground protective shelters have clearly indicated the immediate need for earth temperature design data.[1,2,3] The environment in an underground protective shelter can be improved considerably if the heat absorbing capacity of the surrounding earth is effectively utilized. The total heat absorbing capacity of earth, however, cannot be accurately determined unless its temperature and thermal properties are known. The earth temperature varies with latitude, weather conditions, time of year, altitude, landscaping, shading, neighboring buildings, earth surface conditions, soil properties, rainfall, and other factors.

Although the exact ground temperature at a specific site can be obtained only by direct measurements, information on the general distribution of the natural ground temperature throughout the United States is, nevertheless, worth obtaining. Such information would be useful from the standpoint of shelter planning on a nationwide basis and would aid in determining the equipment requirements for ventilation, air-conditioning and heating of various size shelters.

The primary purpose of this report is to compile all available annual cycles of monthly average earth temperatures in the depths suited to heat transfer calculations in underground protective structures.

Numerous earth temperature data are scattered throughout the literature, but little effort has been made in the past to compile them into a nationwide summary except for the work of Fitton and Brook[4] and that of Jen-Hu Chang.[5] A good many of the earth temperature data compiled by these workers have, however, been obtained less than a foot from the earth's surface and are not particularly suited for heat transfer studies on underground structures.

For heat transfer studies on underground protective structures, earth temperatures at depths between 3 ft and 10 ft are of particular significance. A study was undertaken under the sponsorship of the Office of Civil Defense to secure earth temperature data at these depths from several existing soil temperature records,[4,5,6,7,8,9,10] either published or unpublished. Data compiled and analyzed in this paper are monthly average earth temperatures for periods ranging from one year to several years.

The analysis of earth temperature data includes the following parts:

(a) The determination of averaged annual cycles of monthly average earth temperatures at various depths from the several years' records at 63 stations.

(b) Least-squares fitting of observed data to a simple harmonic function to obtain annual average temperature, annual amplitude of monthly averages, and phase angle of the temperature cycle at various depths for 63 stations.

(c) Calculation of thermal diffusivity of the earth at 29 stations using both the amplitude and phase angle techniques.

(d) Comparison of observed earth temperatures with calculated earth temperatures, using the thermal diffusivity as determined in (c) and with least-squares constants as determined in (b) at each depth where the observations were made.

(e) Calculation of earth temperature from the surface to a depth of 10 ft at two-foot intervals and average earth temperature of the same region for selected values of thermal diffusivities and earth temperature characteristics.

In order to compare the earth temperatures with air temperatures, annual temperature cycles of outdoor air were also collected from weather stations in the vicinity of the ground temperature stations. The earth temperatures were also compared with ground water temperatures reported by Collins.[11]

2. Location of Earth Temperature Stations

The many parameters which affect earth temperature can be classified into the following three major groups:

(1) Geographical characteristics: latitude, altitude, climatic conditions.

(2) Site characteristics: surface condition, landscaping, shading, neighboring installations, water table.

(3) Earth characteristics: thermal and physical properties of earth (including moisture content), packing density, etc.

Since many of these parameters change in a seasonal cycle, or irregularly with time, it is impossible to predict exactly the earth temperature at any given location for any given time in the future, particularly at locations near the earth's surface. Earth temperature predictions, therefore, are of a statistical nature and some deviation from the average is to be expected in any given day, season, or year.

Because earth temperatures are affected by so many factors, it would be desirable in analyzing data at different locations for comparison with each other to keep as many of these factors, such as earth cover, shading, and earth density, constant in order to arive at meaningful conclusions. However, this approach was impractical for the most part in the present study since the original temperature data were taken for a variety of purposes by different investigators, and the total number of stations of observation in the United States was quite limited. The majority of the ground temperature data available for this study were obtained in undisturbed earth at stations on open flat ground, either bare or grass-covered.

The geographical locations of the stations for which earth temperature data are compiled in this study are indicated in Fig. 1. Collins' well-water temperature isotherms[11] at depths of 30 ft to 60 ft are superimposed on Fig. 1. These data will be used later to correlate the ground water temperature with earth temperature. Eighteen filled circles and seven open circles on Fig. 1 indicate the stations for which data have been newly analyzed during the course of this study. The monthly average earth temperatures for three consecutive years' span were obtained and analyzed for the majority of these twenty-five stations. The stations marked with/bisected open circles in Fig. 1 are those for which earth temperature data had already been reduced to an annual cycle of average monthly temperatures by other investigators for publication. Unfortunately, the majority of the data obtained from these latter sources did not contain pertinent information with regard to most of the site and soil characteristics, although they are still helpful in studying the effect of the parameters which were cited.

A total of 53 sets of data has been compiled and analyzed in this study to show the effect of combinations of the above parameters on earth temperature. Table 1 is a list of the earth temperature stations indicated in Fig. 1.

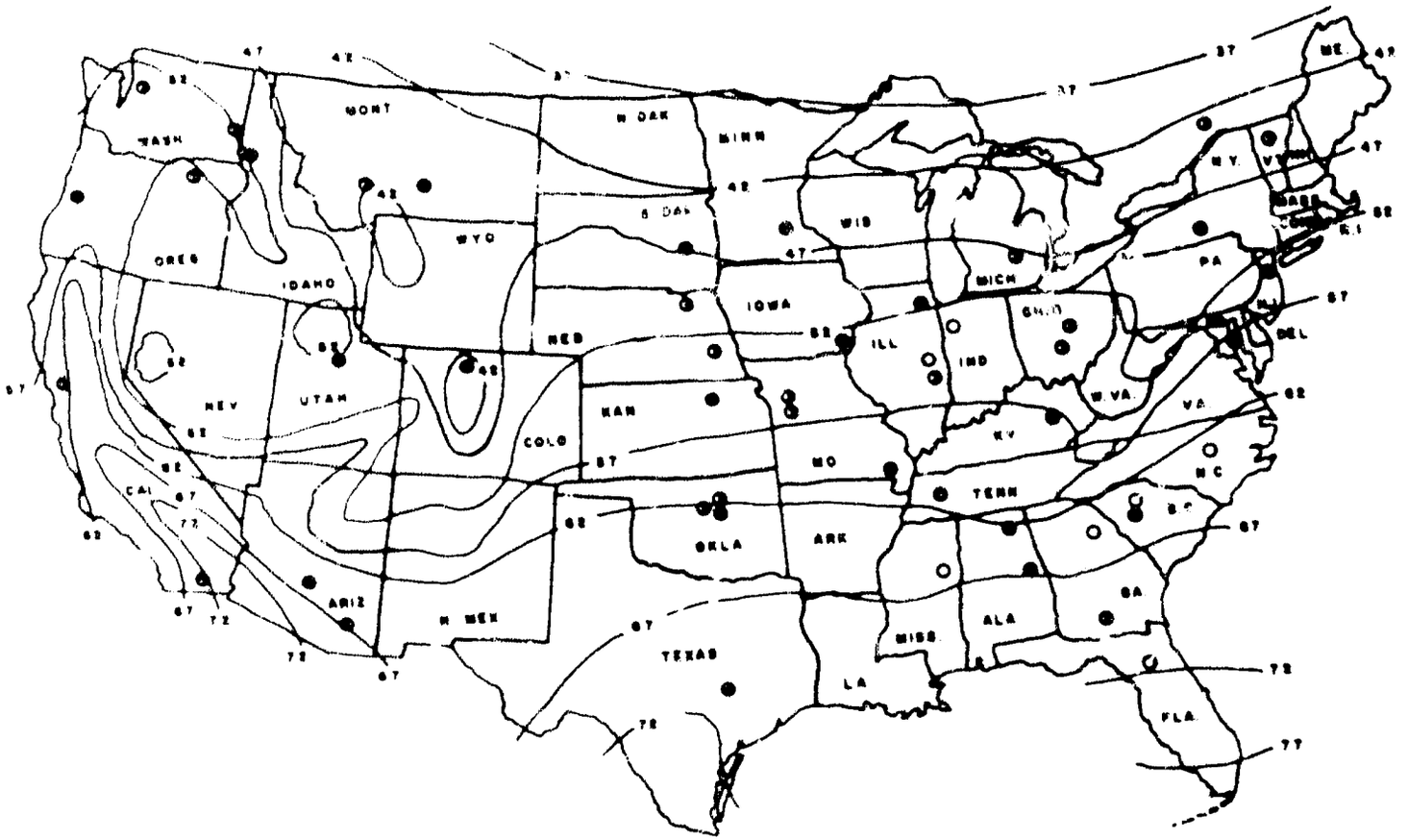

Figure 1 Graphical distribution of stations for which earth temperature data are reported and Collins' well-water isotherms for the 48 contiguous states

Table 1 List of earth temperature stations and results of least-squares analysis

Table	Station	State	Annual Avg. Earth Temp. (A) °F	Temp. Amplitude at Earth's Surface (B0) °F	Phase Angle of Earth Temp. at Surface (P0) radians
*ST- 1	Auburn	Alabama	65	17	0.49
✓*ST- 2	Decatur	Alabama	59	21	0.45
✓*ST- 3	Tempe	Arizona	70	20	0.47
*ST- 4	Tucson	Arizona	75	18	0.77
✓*ST- 5	Brawley	California	79	20	0.60
ST- 6	Davis	California	66	19	0.63
✓ ST- 7	Fort Collins	Colorado	50	24	0.54
✓ ST- 8	Fort Collins	Colorado	50	24	0.54
✓*ST- 9	Fort Collins	Colorado	50	26	0.54
✓ ST-10	Gainesville	Florida	74	--	--
✓ ST-11	Athens	Georgia	67	--	--
ST-12	Tifton	Georgia	71	--	--
*ST-13	Moscow	Idaho	47	18	0.73
*ST-14	argonne	Illinois	51	23	0.70
ST-15	Lemont	Illinois	52	23	0.66
*ST-16	Urbana	Illinois	53	25	0.62
ST-17	Urbana	Illinois	55	--	--
*ST-18	West Lafayette	Indiana	52	--	--
✓*ST-19	Burlington	Iowa	54	30	0.57
✓*ST-20	Manhattan	Kansas	55	26	0.61
ST-21	Lexington	Kentucky	55	23	0.60
*ST-22	Lexington	Kentucky	58	22	0.75
✓*ST-23	Upper Marlboro	Maryland	56	25	0.56
ST-24	East Lansing	Michigan	50	24	0.60
ST-25	East Lansing	Michigan	51	24	0.59
ST-26	East Lansing	Michigan	50	24	0.60
ST-27	East Lansing	Michigan	50	24	0.60
ST-28	East Lansing	Michigan	50	24	0.65
✓*ST-29	St. Paul	Minnesota	48	25	0.65
✓ ST-30	State Univ.	Mississippi	67	21	0.58
*ST-31	Faucett	Missouri	54	20	0.65
ST-32	Kansas City	Missouri	54	22	0.56
✓*ST-33	Sikeston	Missouri	57	25	0.59
*ST-34	Bozeman	Montana	44	21	0.68
✓ ST-35	Bozeman	Montana	44	21	0.63
✓*ST-36	Huntley	Montana	50	25	0.47
ST-37	Lincoln	Nebraska	54	28	0.52
ST-38	Lincoln	Nebraska	53	28	0.52
ST-39	Norfolk	Nebraska	53	24	0.54
ST-40	New Brunswick	New Jersey	53	21	0.69
ST-41	Ithaca	New York	49	19	0.69
✓*ST-42	Ithaca	New York	49	19	0.64
✓ ST-43	Raleigh	North Carolina	62	--	--
✓ ST-44	Columbus	Ohio	53	22	0.65
ST-45	Coshocton	Ohio	52	22	0.67
ST-46	Barnsdall	Oklahoma	65	21	0.65
ST-47	Hominy	Oklahoma	63	21	0.73
ST-48	Lake Hefner	Oklahoma	64	23	0.63
ST-49	Pawhuska	Oklahoma	62	22	0.61
*ST-50	Ottawa	Ontario	47	21	0.64
✓*ST-51	Corvallis	Oregon	56	18	0.53
ST-52	Pendleton	Oregon	53	26	0.48
ST-53	Calhoun	South Carolina	64	22	0.49
*ST-54	Union	South Carolina	59	20	0.67
✓*ST-55	Madison	South Dakota	47	26	0.59
✓*ST-56	Jackson	Tennessee	60	20	0.44
✓*ST-57	Temple	Texas	70	21	0.58
✓*ST-58	Temple	Texas	71	21	0.59
✓*ST-59	Salt Lake City	Utah	51	21	0.48
ST-60	Burlington	Vermont	49	--	--
ST-61	Pullman	Washington	48	--	--
ST-62	Pullman	Washington	48	19	0.50
*ST-63	Seattle	Washington	53	15	0.64

* = Earth temperature stations where the data are analyzed for the thermal diffusivity (29 stations)

✓ = Earth temperature data newly acquired (25 stations)

3. Analysis of Earth Temperature Data

The observed earth temperatures at various depths, averaged arithmetically in monthly periods, were tabulated for the 63 stations in Tables ST-1 through ST-63. In addition to presenting the annual cycle of monthly average earth temperatures, the observed earth temperatures were analyzed to find best annual averages, depth amplitude, and depth phase angles based upon the assumption that the earth temperature can be represented by a simple harmonic time function. This assumption may not represent the best possible mathematical model from the standpoint of meteorological or geophysical considerations, but it is probably satisfactory for the purpose of analysis of heat transfer in underground protective structures. The simple harmonic representation of an annual cycle of monthly average soil temperatures is reasonably accurate, as shown by the analyses of Penrod[8,9] and Carson.[10] Moreover, the constants of the simple harmonic expression of the earth temperature cycle can be related to thermal diffusivity of the soil at any station for which temperature data are taken.

Equation (1) is a simple harmonic function that can be used to represent an earth temperature cycle.

$$t = A - B \cos\left(\frac{2\pi}{T}\theta - P\right) \qquad (1)$$

where: t is the monthly average earth temperature, °F

θ is the time coordinate which is taken as zero on January 1, hr

T is the period of the temperature cycle = 8766 hr

A is the annual average earth temperature, °F

B is the annual amplitude of the monthly average temperature cycle, °F

P is the phase angle of the earth temperature cycle, radians.

The values of A, B, and P in equation (1) have been determined in two different ways by other authors. Penrod[8,9] computed A by arithmetic average of 12 monthly average earth temperatures, B as one-half the difference between the maximum and minimum monthly average temperatures, and P by a rather complicated graphical calculation. Carson[10] expressed the annual cycle of monthly average earth temperatures at a given depth by a Fourier series containing six harmonics and computed A, B, and P from the basic harmonic terms of the Fourier expression. Both Penrod and Carson computed their parameters for each year separately.

It should be pointed out, however, that the numerical value of P is rather arbitrary, depending upon the origin of the time coordinate system.

In this study, earth temperature cycles of several years' record of monthly averages have been fitted to equation (1) by a least-squares method. That is, the values of constants A, B, and P have been determined, so that the sum of the squares of differences between the fitted harmonic curve and the observed values are a minimum. Fig. 2 shows typical annual cycles of monthly average earth temperatures at the surface and at the 10-ft depth at a site in Lexington, Kentucky. Curves representing the 5-year norm of Penrod,[9] and those calculated by the least-squares technique are also shown on Fig. 2. A good agreement exists between the least-squares fitted curve and the 5-year norm curve, despite the considerable scatter in earth surface temperature data.

The detail of the mathematical development of the least-squares technique is presented in the Appendix. The values of A, B, and P, and the standard deviation of the observed data from the value calculated by equation (1), were determined at each depth for 63 sets of earth temperature data and are shown in the ST tables. The absolute value of the phase angle, P, is dependent upon the coordinate system of Θ of equation (1) and is less meaningful than the difference between the values of P at two consecutive depths. As seen from the ST tables, the annual amplitude of the earth temperature, B, decreased as the depth increased, whereas the annual average of the earth temperature was practically invariant with respect to the depth, except for irregularities near the surface region. It is also observed from the ST tables that the phase angle, P, increased as the depth increased.

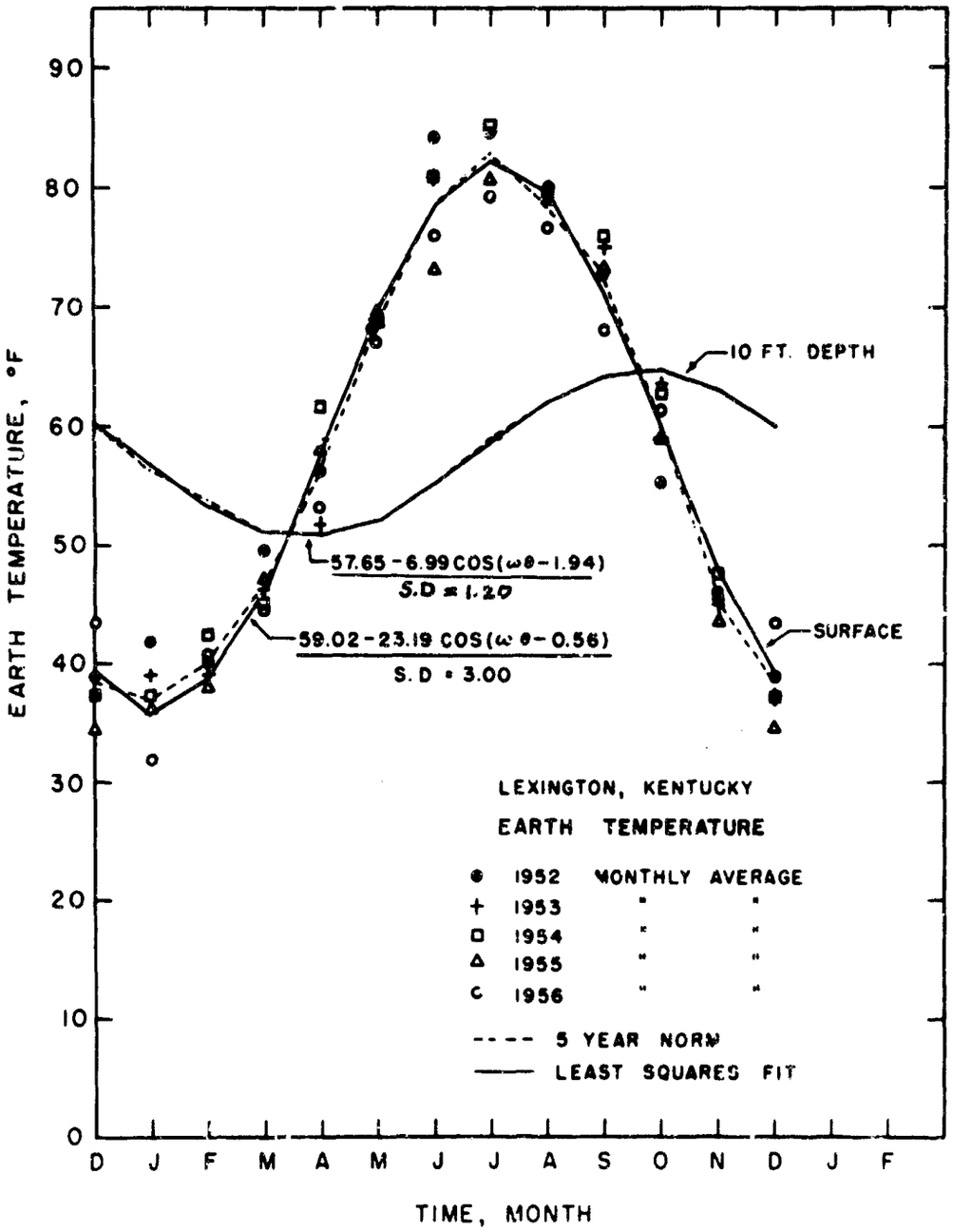

Figure 2 Comparison of least-squares curve, 5-year norm, and observed temperatures at Lexington, Kentucky

4. Simplified Heat Conduction Theory of Undisturbed Earth

The earth temperature oscillation near the surface from the standpoint of heat conduction theory has been discussed in various texts of heat transfer; notable among them are Carslaw and Jaeger's[12] and Eckert's[13] treatments of the problem.

Usually the mathematical treatment of earth temperature starts with the assumption that:

(1) Earth is a homogeneous heat conducting medium of a semi-infinite solid system, the thermal diffusivity of which is constant throughout.

(2) The temperature of the surface exposed to the atmosphere varies periodically with time.

For such a system the earth temperature at depth, x, can be computed by the following equation when a steady cyclic pattern is established within earth:[12,13]

$$t = A + \sum_{n=1}^{\infty} e^{-\sqrt{\frac{n\pi}{DT}}\,x} \, Cn \cos\left(\frac{2\pi n\Theta}{T} - \delta n - \sqrt{\frac{n\pi}{DT}}\,x\right) \qquad (2)$$

where Cn and δn correspond to the amplitude and phase angle of the nth harmonic of the prescribed periodic temperature function at the ground surface. As long as the earth surface temperature is periodic, and as long as the assumptions (1) and (2) are valid, equation (2) exactly describes the earth temperature with proper evaluation of Cn and δn as well as thermal diffusivity D. Furthermore, when higher harmonics corresponding to $n \geq 2$ are not significant, as in the case of the annual temperature cycle of the monthly average soil temperatures, equation (2) becomes simply the following form:

$$t = A - BO\, e^{-\sqrt{\frac{\pi}{DT}}\, x} \cos\left(\frac{2\pi\theta}{T} - \sqrt{\frac{\pi}{DT}}\, x - PO\right) \qquad (3)$$

By comparing (1) and (3), $$B = BO\, e^{-\sqrt{\frac{\pi}{DT}}\, x} \qquad (4)$$

and $$P = PO + \sqrt{\frac{\pi}{DT}}\, x \qquad (5)$$

Relations (4) and (5) indicate that a linear relationship exists between the logarithmic amplitude and depth and between the phase angle and the depth.

Relations (4) and (5) also suggest the evaluation of thermal diffusivity by the formulas

$$D\,(B) = \frac{\pi}{T}\left[\frac{x}{\log \frac{BO}{B}}\right]^2 \qquad (6)$$

$$D\,(P) = \frac{\pi}{T}\left[\frac{x}{P - PO}\right]^2 \qquad (7)$$

The preceding relations of earth temperature and thermal diffusivity had been applied as far back as 1811 by Lord Kelvin to the mean earth temperature curves based on Forbe's 18-year record in Edinburgh, Scotland.[12/] Kelvin did not ignore the higher harmonics for the temperature equations and calculated the diffusivity not only by the first harmonic but also by the higher harmonics as well. He had obtained a good agreement between the thermal diffusivities deduced from the amplitude and that from the phase angle of the first harmonic. He was, however, less successful for the higher harmonics in obtaining a good agreement between the diffusivities calculated by the two different methods.

5. Analyses of Thermal Diffusivity of the Earth by Simplified Theory

Several other investigators have applied the simplified theory of the preceding section to limited amounts of earth temperature data. In this analysis, the results of the least-squares fitting for several earth temperature stations were selected for graphical representation of amplitude and phase angle with respect to depth. Figures ST-1 through ST-19 indicate relations between logarithmic amplitude (log B) vs. depth, x, whereas Figures SP-1 through SP-19 show relationships between the phase angle, P, and the depth, x, for the data obtained from 19 earth temperature stations.

It can be said for all of 19 stations, except near the region of x=o, linear relationships between log B and x, and those between P and x, are eminent from all of the ST and SP series of charts. The temperature irregularity near the ground surface can be explained as follows:

(1) The earth surface region differs from the idealized heat conduction model of the previous discussion. The temperature pattern is complicated due to the fact that irregular daily fluctuations of weather influence the surface temperature.

(2) Temperature values are influenced by the time of observation unless the data are the average of the continuous hourly recording.

(3) The soil near the earth's surface is usually less homogeneous than at depth.

The density, water content, and composition vary within the region.

The temperature data for 29 of the 63 stations covered a sufficient range of depths below the earth's surface to be suitable for evaluating thermal diffusivity, and earth surface temperature amplitude and phase angle by graphical methods. Those 29 earth temperature stations are identified by asterisks in Table 1. On each of the charts for those 29 stations, some of which have been illustrated in Figures ST-1 to 19, a straight edge was placed to fit the log B vs. depth data points by a visual inspection, such that the points at greater depths controlled the positions as well as the slopes of the straight edge. This visual technique was considered more appropriate for the analysis than a mathematical regression technique because most of the temperature data were concentrated near the shallow depth region where inconsistency with respect to the basic heat transfer theory is predominant due to heterogeneity of the material and diurnal effects. The visual technique did help to avoid obscuring the intrinsic linear relation of log B vs. X and P vs. X manifested in the deep earth temperature data by abundant shallow depth data. The earth surface temperature amplitude BO was then read at the intersecting point of the straight edge and the x=0 coordinate line. The slope of the straight edge thus determined was also used for calculating thermal diffusivity D(B) by equation (6). Figures SP-1 through SP-19 show the plots of phase angles vs. depths calculated for the same 19 stations, the logarithmic amplitudes of which have been analyzed. A similar visual technique of finding the intercepts and slopes of the plots on log B vs. X was also employed on these phase angle-depth plots in determining the earth surface temperature phase angle and thermal diffusivity D(P).

The simplified theory demands that the diffusivities computed by the slope of log B-x relation and that of P-x relation must agree. The thermal diffusivities computed by the two methods are summarized in Table 2 for eighteen selected stations where comprehensive information on earth temperature site characteristics was available. Fig. 3 graphically correlates the relationship between the two computed diffusivity values, D(B) and D(P). Of all the sets compared, eight showed an excellent agreement for the diffusivities computed by the amplitude method and phase lag method. A majority of the comparisons showed the diffusivity computed by the phase lag method to be lower than that computed by the amplitude method. No obvious correlation existed between the difference in the two thermal diffusivity values and earth temperature site characteristics, such as type of soil, elevation, earth surface, temperature level, or geographical location. Although it may be accidental, all three of the stations with bare earth cover showed very good agreement between the two diffusivities.

The difference between the thermal diffusivities computed by equations (6) and (7) may be attributable to the following conditions:

(1) Errors in assigning correct slopes for log B-x and P-x curves due to the insufficient depth data as well as inconsistent temperature-depth data.

(2) Errors in calculating correct phase angle and amplitude from insufficient and fluctuating data.

Table 7 Summary of site characteristics and earth, air, and ground water thermal characteristics at 18 selected stations

Location	Elevation ft	Soil	Earth Cover	Maximum Temperature Data Depth in.	Annual Average Air Temperature °F (TA)	Ground Water Temperature °F (TW)	Annual Average Earth Temperature °F (A)	Annual Earth Surface Temperature Amplitude °F (BO)	Annual Amplitude of Air Temperature °F (BA)	Thermal Diffusivities Ft²/hr Amplitude Method D(A)	Thermal Diffusivities Ft²/hr Phase Angle Method D(P)
Decatur, Ala.	588	Silt Loam	Grass	72	61	62	59	21	21	0.032	0.015
Yuma, Ariz.	1180	Sand	Citrus Grove	89	70	67	70	20	20	0.027	0.026
Brawley, Calif.	-100	Silt Clay	Bare	79	73	73	79	20	20	0.019	0.019
Ft. Collins, Colo.	5000	Loam	Sparse Vegetation	72	50	42	50	26	21	0.020	0.029
Argonne, Ill.	600	Sandy Clay	Grass	348	50	52	51	23	25	0.026	0.027
Burlington, Iowa	694	Silt Loam	Cultivated	72	52	52	54	26	26	0.023	0.014
Manhattan, Kans.	1106	Silt Clay	Blue Grass	96	54	55	55	27	26	0.019	0.026
Lexington, Ky.	969	Silt Clay	Sod	120	55	56	58	21	21	0.029	0.025
Upper Marlboro, Md.	98	Sandy Loam	Bare	59	57	57	56	25	21	0.039	0.036
St. Paul, Minn.	838	Silt Loam	Sod	126	43	45	48	25	31	0.033	0.028
Sikeston, Mo.	325	Sandy Loam	Grass	72	60	56	57	24	22	0.042	0.027
Huntley, Mont.	3500	Clay	Sod	60	47	42	50	24	25	0.028	0.012
Ithaca, N.Y.	400	Loam	Sod	96	48	47	49	19	23	0.026	0.021
Corvallis, Oreg.	225	Clay Loam	Unknown	40	52	55	56	18	14	0.013	0.011
Madison, S. Dak.	1200	Silt Clay	Grass Sod	40	45	45	47	26	30	0.011	0.009
Jackson, Tenn.	418	Silt Loam	Grass	72	58	60	60	18	19	0.024	0.020
Temple, Texas	440	Clay	Horticultural	48	67	70	70	21	19	0.018	0.019
Salt Lake City, Utah	4244	Sandy Loam	Bare	39	52	52	51	21	25	0.035	0.035

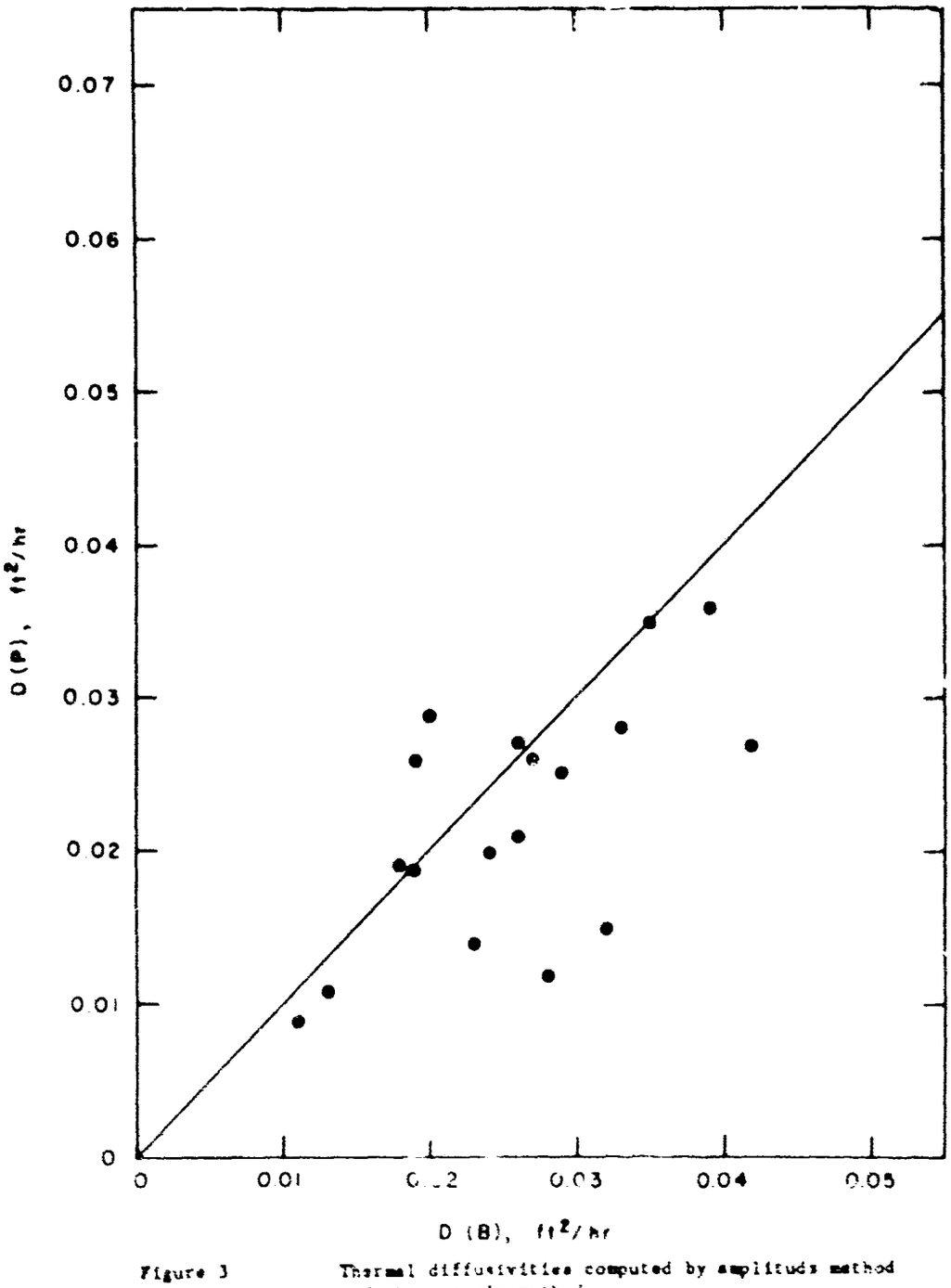

Figure 3 Thermal diffusivities computed by amplitude method and phase angle method

(3) Discrepancies from the ideal one-dimensional heat flow system due to the site characteristics of earth temperature stations of which the authors were unaware.

6. Correlation of Earth, Air, and Ground Water Temperatures

According to Collins,[11] the ground water temperature at a depth of 30 ft to 60 ft is very nearly equal to the annual average air temperature. The well-known Collins' ground water temperature map was constructed on this basis, utilizing the annual average air temperature distribution of the 48 states.

Annual average air temperatures were collected from weather stations located near the earth temperature stations designated by solid dark and open dots in Fig. 1. The list of the weather stations and the data are shown in Table 3. Table 3 also lists the following data:

(1) The annual average air temperature, TA, and the annual amplitude of the monthly average air temperature cycle, BA, computed from the observed data for the indicated period of record.

(2) The least-squares constants, TA', BA', and PA', for the annual average air temperature, the annual amplitude of the monthly average air temperature cycle, and the phase angle of the air temperature cycle, respectively, for the climatological standard normals (1931-1960). These constants were determined in the same manner as those for the earth temperature.

Table 3.--List of air temperature stations located near the earth temperature stations

Air Temperature Station	Near-by Earth Temp. Station of Table 1	Average Air Temp. During Specified Period: Record Period	Annual Average Air Temperature °F (TA)	Half Range of Annual Air Temp. Cycle °F (BA)	Least Squares Fit Results on Climatological Standard Normals (1931 - 1960): Annual Average Temperature °F (TA')	Amplitude of the Annual Cycle °F (BA')	Phase Angle of the Annual Cycle radians (FA')
Huntsville, Alabama	Decatur, Alabama	1959-1961	60.9	20.5	62	20	0.55
Phoenix, Arizona	Tempe, Arizona	1905-1961	70.2	19.5	71	20	0.60
Tucson, Arizona	Tucson, Arizona	1905-1961	67.4	17.9	68	18	0.62
Yuma, Arizona	Brawley, Calif.	1905-1961	72.6	18.5	75	18	0.63
Denver, Colorado	Fort Collins, Colo.	1905-1961	50.3	21.2	51	22	0.63
Washington, D.C.	Upper Marlboro, Md.	1920-1961	57.3	20.8	57	21	0.60
Orlando, Florida	Gainesville, Fla.	1910-1961	72.4	10.8	72	11	0.64
Athens, Georgia	Athens, Georgia	1906-1961	61.7	17.6	62	19	0.56
Springfield, Ill.	Urbana, Illinois	1905-1961	53.4	24.8	53	25	0.60
South Bend, Indiana	West Lafayette, Ind.	1905-1961	49.5	24.3	50	25	0.63
Burlington, Iowa	Burlington, Iowa	1905-1961	51.7	26.1	51	26	0.59
Concordia, Kansas	Manhattan, Kansas	1905-1961	53.8	25.8	55	26	0.61
Lexington, Ky.	Lexington, Ky.	1906-1961	55.3	21.2	56	22	0.60
St. Cloud, Minn.	St. Paul, Minn.	1905-1961	42.5	30.6	42	30	0.60
Meridian, Miss.	State Univ., Miss.	1910-1961	64.7	16.4	65	18	0.53
Springfield, Mo.	Fairgett, Missouri	1905-1961	56.0	21.9	57	23	0.60
Billings, Montana	Bozeman, Montana	1935-1961	47.3	24.9	47	24	0.63
Lincoln, Nebraska	Lincoln, Nebraska	1905-1961	51.8	26.8	53	27	0.61
Syracuse, New York	Ithaca, New York	1912-1961	47.8	23.4	48	25	0.65
Raleigh, N. Carolina	Raleigh, N. Carolina	1906-1961	60.2	18.2	60	19	0.56
Columbus, Ohio	Columbus, Ohio	1906-1961	52.5	22.6	53	23	0.60
Eugene, Oregon	Corvallis, Oregon	1905-1961	52.2	13.8	53	13	0.63
Huron, South Dakota	Madison, South Dakota	1905-1961	44.6	30.3	46	30	0.59
Oak Ridge, Tenn.	Jackson, Tenn.	1948-1961	58.4	19	59	20	0.55
Waco, Texas	Temple, Texas	1905-1961	67.4	18.8	67	19	0.58
Salt Lake City, Utah	Salt Lake City, Utah	1905-1961	51.7	24.5	51	23	0.59
Walla Walla, Wash.	Pullman, Wash.	1905-1961	53.8	21.3	54	20	0.56

NOTE: All the air temperature data are obtained from Local Climatological Data of U.S. Weather Bureau

It can be seen from Table 3 that the values of TA and TA' and those for BA and BA' are nearly equal.

The values of annual average air temperature TA and the amplitude of the monthly average air temperature BA are superimposed on Figures ST-1 through ST-19, whereas the air temperature phase angle PA is superimposed on Figures SP-1 through SP-19.

Annual average earth temperature, A, and ground water temperature, TW, are plotted against annual average air temperature, TA, in Fig. 4. The annual amplitude of monthly average air temperature, BA, is plotted in Fig. 5 against earth temperature amplitude at the surface BO. Although the annual average earth temperature, A, can be approximated either by the annual average air temperature, TA, or by Collins' water temperature, TW (from Fig. 1), the approximation of BO, the annual earth surface temperature amplitude from the annual amplitude of the monthly average air temperature, BA, is not too satisfactory, as shown by Fig. 5 and all of the figures in the ST series.

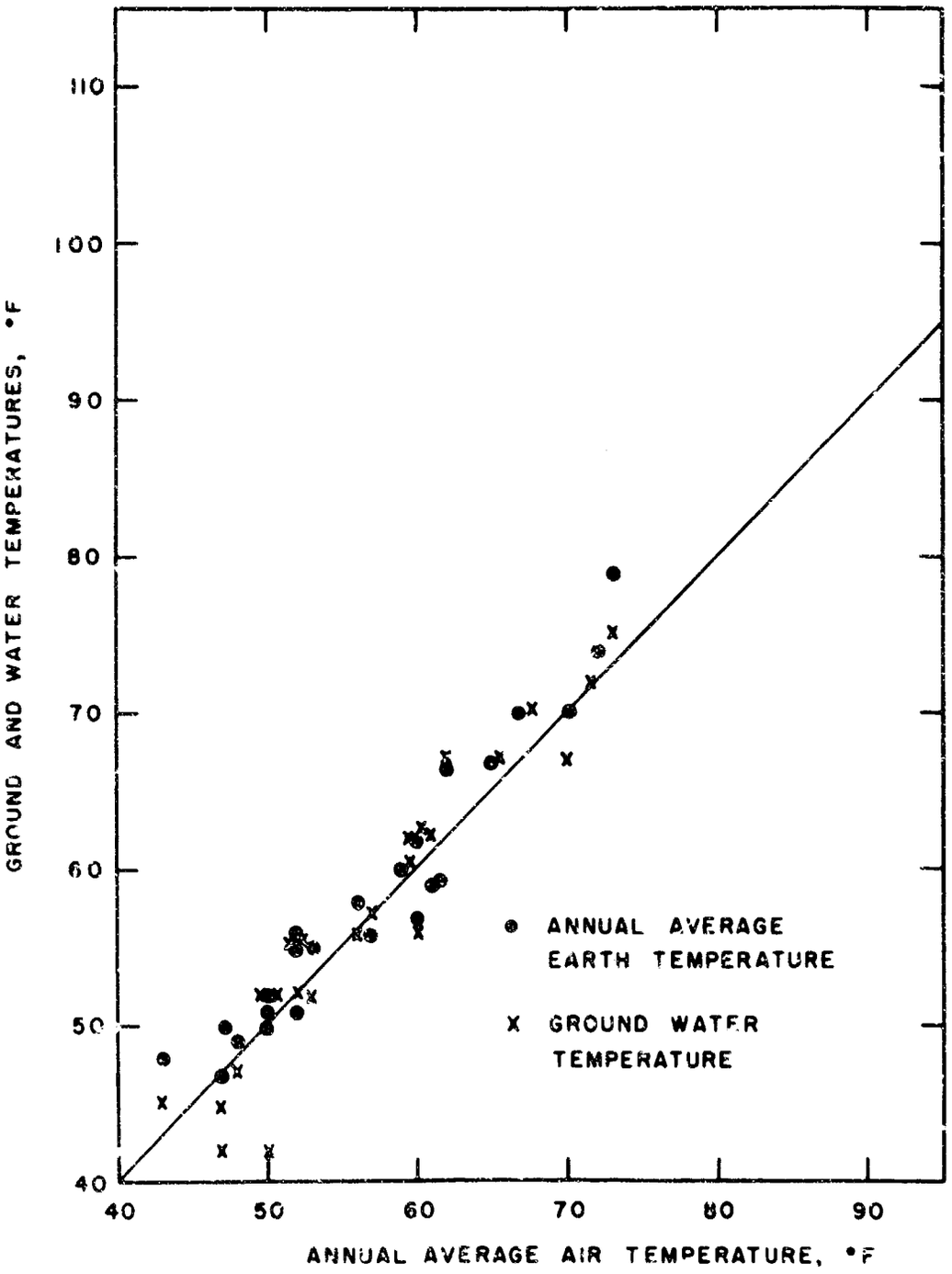

Figure 4 Annual average earth and water temperature vs. annual average air temperature

A close examination of Fig. 5 and Table 2 reveals the following interesting trend, however. The points of BO below the line of BO=BA in Fig. 5, or the localities where BO<BA, represent inland cities such as Ithaca (New York), Salt Lake City (Utah), Madison (South Dakota), and St. Paul (Minnesota). In contrast, the points above the line of BO=BA represent the near-coastal cities such as Gainesville (Florida), Corvallis (Oregon), Oxford (Mississippi), and Upper Marlboro (Maryland), with Fort Collins (Colorado) being an exception. A preliminary study for the Washington, D.C. area and for the Minneapolis (Minnesota) area has been made to compare the amplitudes and phase angles of annual cycles of monthly mean outdoor air temperatures and monthly mean solar radiation received on the flat surfaces for two cities, as shown in Fig. 6, with BO>BA in Washington, D.C. and BO<BA in Minneapolis. Fig. 6 reveals that the Minneapolis area receives slightly more solar radiation during the summer months of July and August and slightly less from October to December than Washington, D.C., and has considerably lower monthly average outdoor air temperature than the Washington, D.C. area throughout the year. Since earth temperature is dependent on both the heat exchange with outdoor air and solar radiation, the relation between BO and BA cannot be explained adequately without including solar effects.

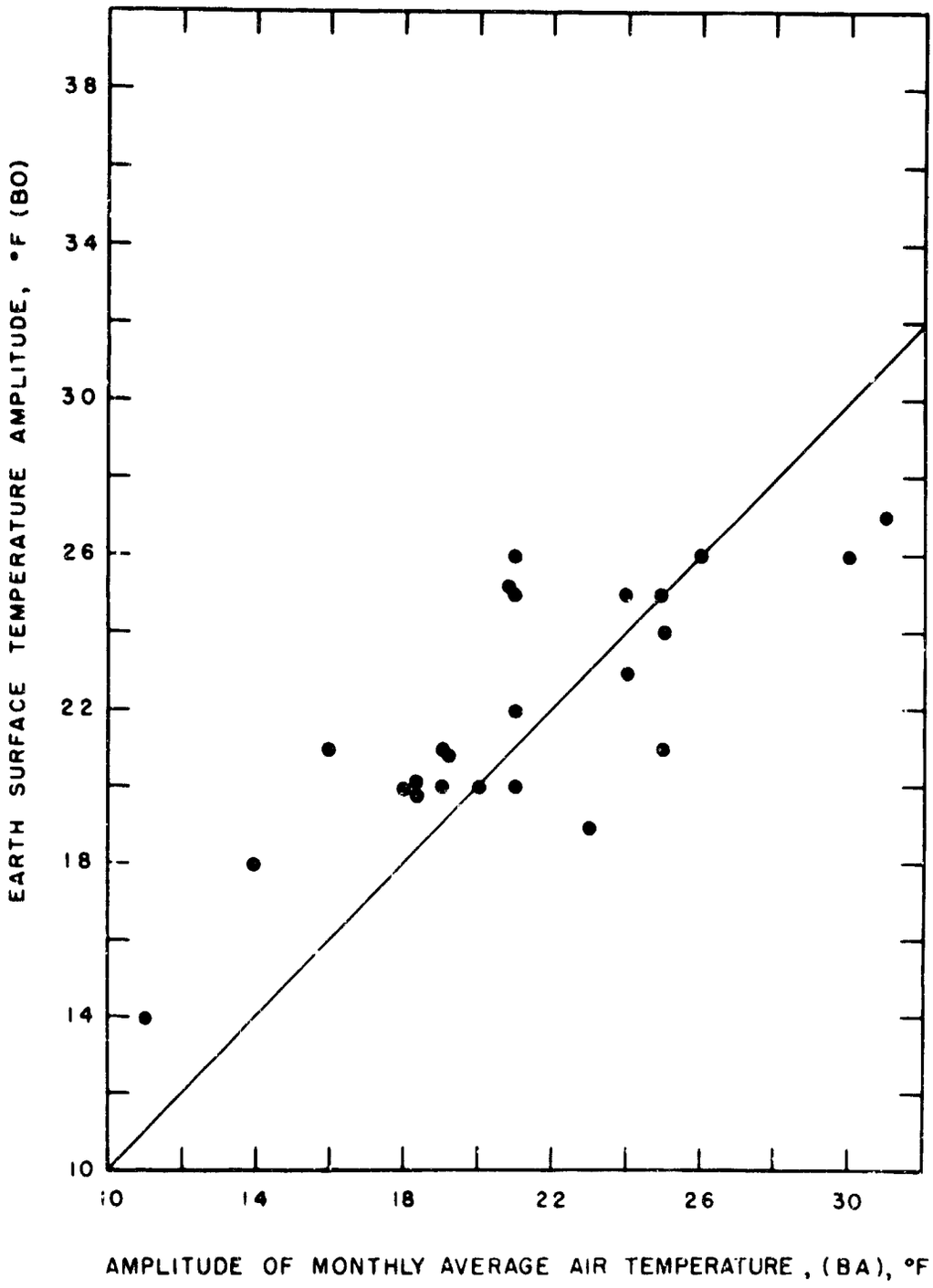

Figure 5 Annual amplitude of monthly average air temperature vs. annual earth surface temperature amplitude

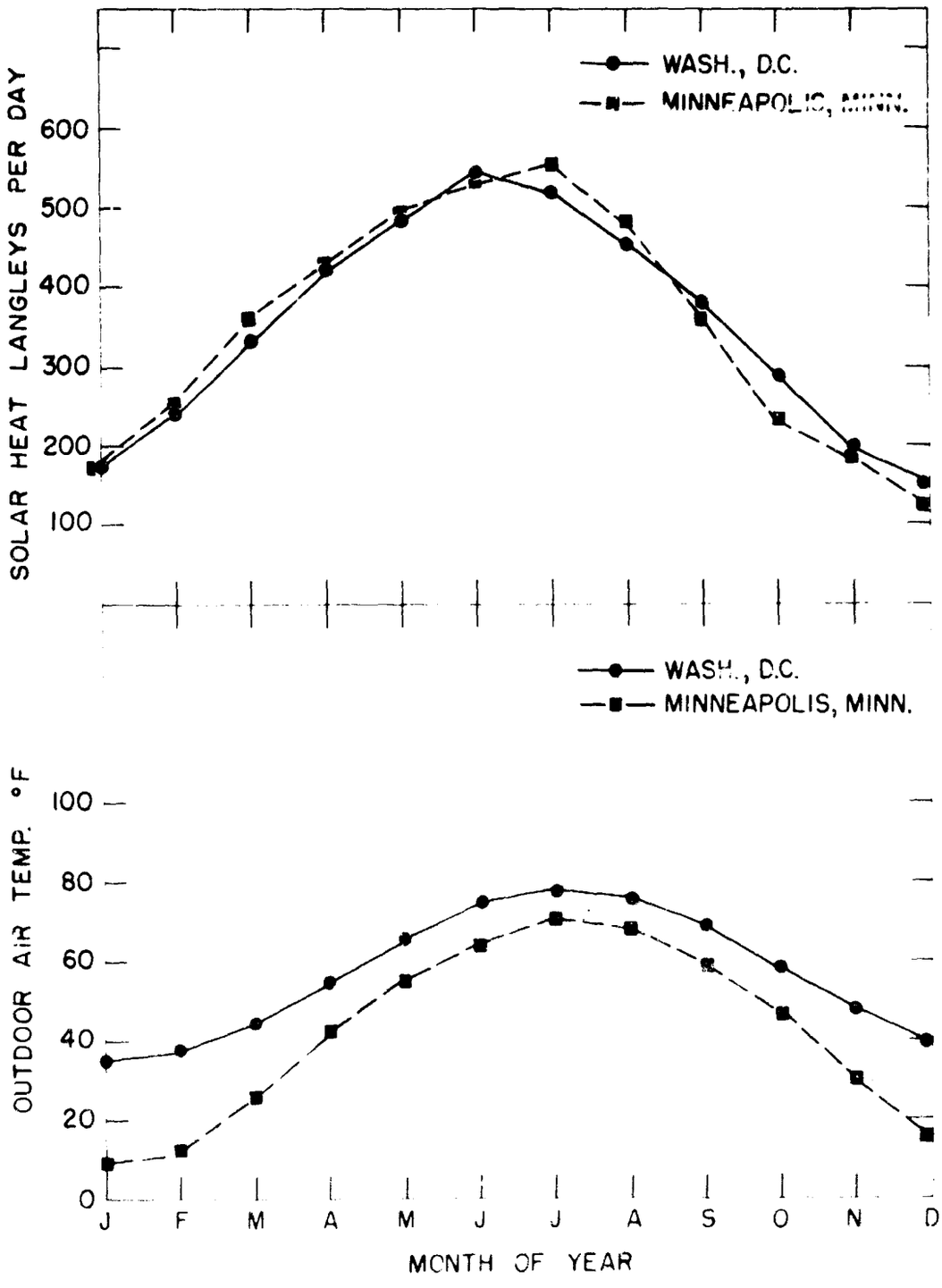

Figure 6 Annual cycles of monthly average daily solar insolation and monthly average outdoor air temperature for Washington, D. C. and Minneapolis, Minnesota

The phase angles of air temperature cycle PA and those of the earth surface temperatures PO are also compared graphically in Fig. 7. The phase angles of annual air temperature cycles are concentrated in a narrow band of 0.6±0.05 radians regardless of the locality, whereas the phase angles of the earth surface temperature are scattered in a much wider range than those of air temperature cycles as can be observed in Fig. 7.

Analytical studies such as made by Lettau[15] for the earth surface heat exchange with respect to outdoor air, solar radiation, sky radiation, evaporation, and nighttime outgoing radiation may give direction to the computation or prediction of BO and PO from the data for BA and PA which are readily available from local weather records.

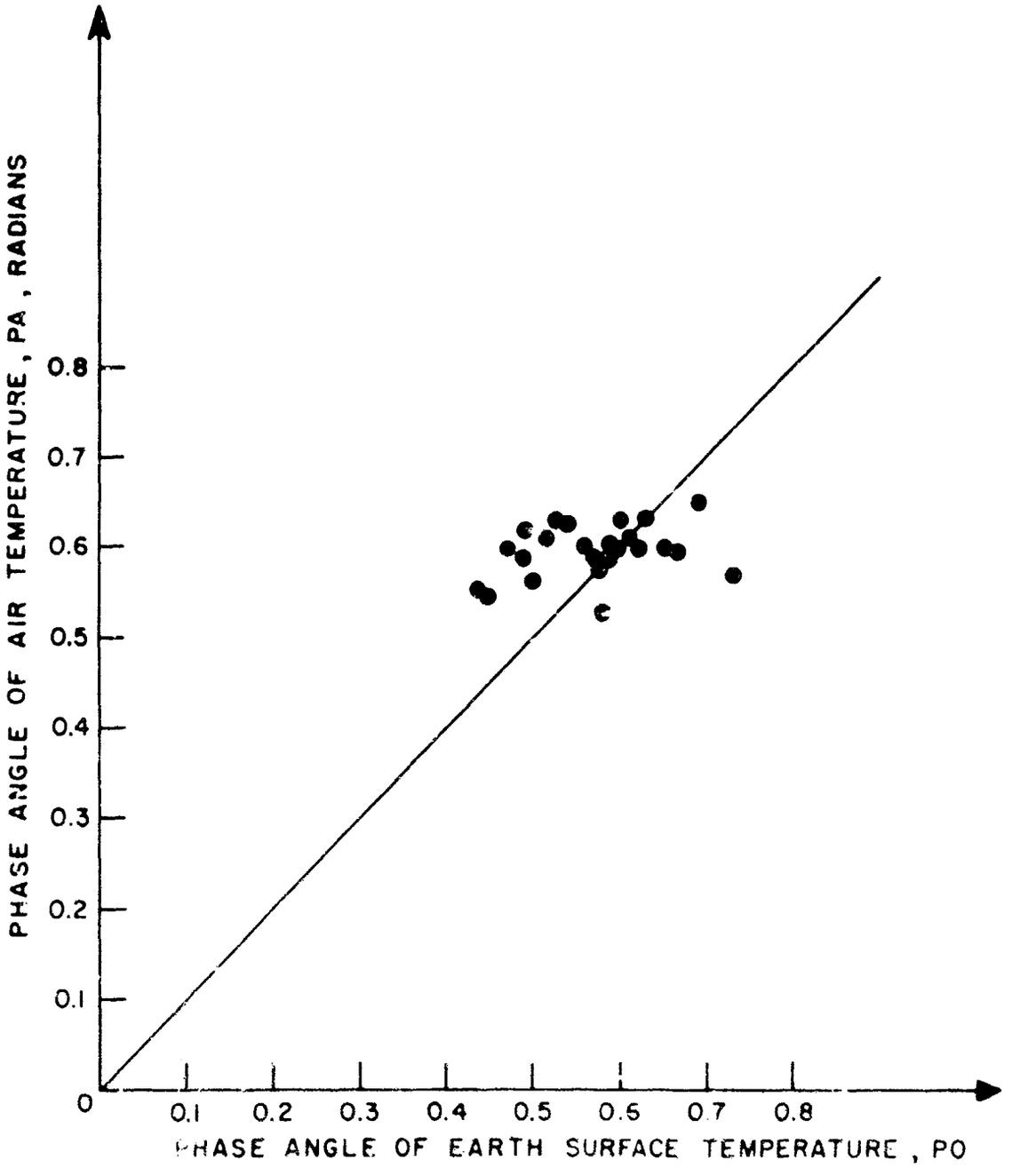

Figure 7 Phase angle relations between the annual cycles of monthly average air and earth surface temperatures

The following general conclusions can be drawn from the foregoing analysis of the data from several selected earth and air temperature stations:

(1) Except near mountain ranges there is a strong tendency toward equality among the annual average air temperatures, TA, the annual average earth temperature, A, and deep ground water temperature, TW. In other words, the annual average ground temperature, A, can be reasonably well estimated by TA or TW.

(2) With somewhat less accuracy, earth temperature amplitude at the undisturbed surface (BO) can be approximated by the amplitude of the annual cycle of monthly average air temperature (BA).

(3) The phase angles of the earth surface temperature cycles do not show a definite correlation with that of annual air temperature cycles. The annual air temperature cycles of various cities in the United States are all approximately in phase with the minimum occurring about at the beginning of February.

7. Calculations of Earth Temperatures

Having developed values for annual average earth temperature, A, the earth surface temperature amplitude, BO, and phase angle, PO, by least-squares technique from the observed data, and knowing the thermal diffusivity, D, of the soil which has been calculated from the least-squares constants at several depths, it was possible to calculate the earth temperature by equation (3). Such calculations were performed with the data of Tables ST-1 through 63 using the arithmetic average of the thermal diffusivities determined by amplitude and phase angle methods. The lower portion of ST tables shows the calculated temperatures for all of the observed depths. The calculations were performed with the use of equation (3) by employing the parameter values indicated at the bottom of the ST tables. The agreement between the calculated and the observed are generally satisfactory, in most instances, particularly at greater depths. The probable reasons for the greater discrepancy between the calculated and the observed earth temperature near the earth surface are described in Section 5.

In many instances, it may be desirable to have a rough approximation of undisturbed earth temperature at a given depth or at several depths where all or some of the constants, A, BO, and PO, and the thermal diffusivity are unknown. As indicated in the previous section, A can be closely approximated by the annual average air temperatures TA, but BO and PO are not closely predictable from air temperature amplitude BA, and phase angle PA. The thermal diffusivities may be determined for a given soil by laboratory test or may be computed by handbook values of thermal conductivity, density and specific heat if the type of soil and its moisture content are known.

The STA tables show computed monthly earth temperatures for all of the 63 earth temperature stations, for depths of 2, 4, 6, 8, and 10 ft, using temperature characteristics, such as A, BO, and PO, taken from the corresponding ST table when available, or otherwise approximated by the air temperature data, and for an arbitrarily chosen thermal diffusivity of 0.025 ft^2/hr, which is an approximate median of all of the thermal diffusivities derived from the observed earth temperature data. In order to examine the effect of thermal diffusivities other than 0.025 ft^2/hr upon the earth temperature, the STA tables also include calculated August earth temperatures for the same depths and same values of A, BO and PO but with diffusivities of 0.01, 0.02, 0.03, and 0.04 ft^2/hr in addition to 0.025 ft^2/hr.

8. Integrated Average Temperature of Upper 10-ft Stratum

Although the earth temperature distribution with respect to depth is important for the accurate numerical calculation of heat transfer for underground protective shelters,[2] simplified analytical solutions currently available[16,17] require only an average earth temperature surrounding the shelter at the time of entry. This simplification is employed principally because the heat conduction problem becomes very complicated for complex initial temperature conditions.

By integrating equation (3) with respect to x from the surface to depth L, an average temperature $\bar{t}_L$ can be obtained for this range of depths as follows:

$$\bar{t}_L = \frac{1}{L}\int_o^L \left\{A - BO\, e^{-\sqrt{\frac{\pi}{DT}}\,x}\cos\left(\frac{2\pi\Theta}{T} - PO - \sqrt{\frac{\pi}{DT}}\,x\right)\right\}dx$$

$$= A + \frac{BO}{2\sqrt{\frac{\pi}{DT}}\,L}\left[e^{-\sqrt{\frac{\pi}{DT}}\,L}\left\{\sin\left(\frac{2\pi\Theta}{T} - PO - \sqrt{\frac{\pi}{DT}}\,L\right)\right.\right.$$

$$\left.\left. + \cos\left(\frac{2\pi\Theta}{T} - PO - \sqrt{\frac{\pi}{DT}}\,L\right)\right\} - \left\{\sin\left(\frac{2\pi\Theta}{T} - PO\right) + \cos\left(\frac{2\pi\Theta}{T} - PO\right)\right\}\right] \quad (8)$$

By denoting

$$\beta = \sqrt{\frac{\pi}{DT}}\, L$$

$$\Gamma = \sqrt{\frac{e^{-2\beta} - 2\cos\beta e^{-\beta} + 1}{2\beta^2}}$$

and $$\phi = \tan^{-1}\frac{1 - e^{-\beta}(\cos\beta + \sin\beta)}{1 - e^{-\beta}(\cos\beta - \sin\beta)} ,$$

equation (8) can be reduced to the following expression

$$\frac{\bar{t}_L - A}{BO} = -\Gamma\cos\left(\frac{2\pi\theta}{T} - PO - \phi\right) \qquad (9)$$

The integrated average $\bar{t}_L$ for $o \leq x \leq L$ can then simply be evaluated by knowing β in addition to A, BO and PO, since Γ and φ are functions of β alone. Fig. 8 shows Γ and φ as a function of β in order to assist in making the calculation of the integrated average temperature. Fig. 9 shows the computed August and February earth temperature plotted against depth for Lexington, Kentucky. The integrated average values are also illustrated at 10-ft, 16-ft, and 20-ft depths.

Contemporary underground fallout shelters have approximately 3-ft earth cover over the roof, and their ceiling heights are usually in the range of 7 ft to 10 ft. The temperature of earth surrounding the shelter is usually affected little during the 14-day occupancy period, beyond a region that extends outwardly 5 ft from the shelter walls including the floor.[2/]

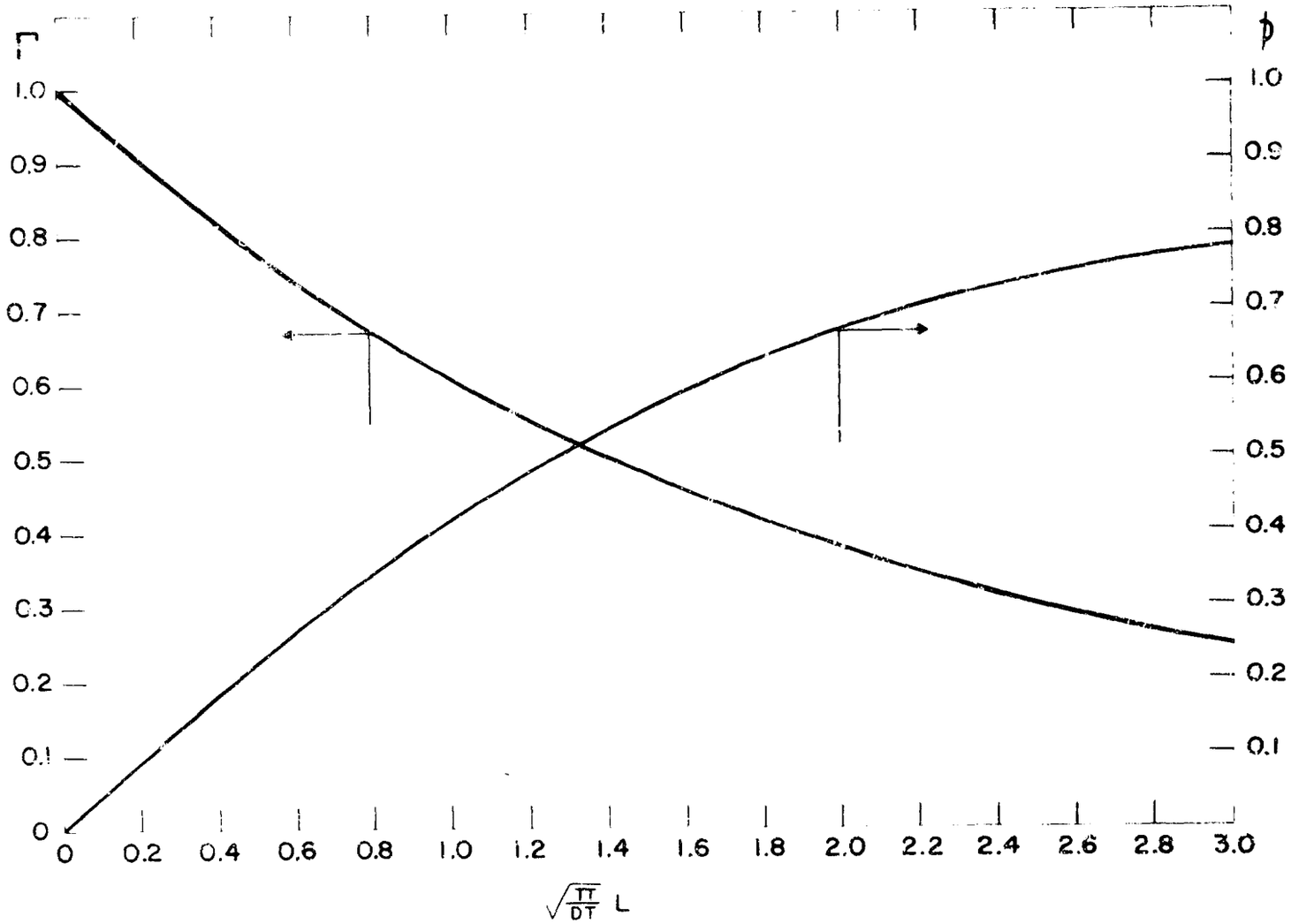

Figure 8 Dimensionless parameters for calculation of integrated depth average earth temperature

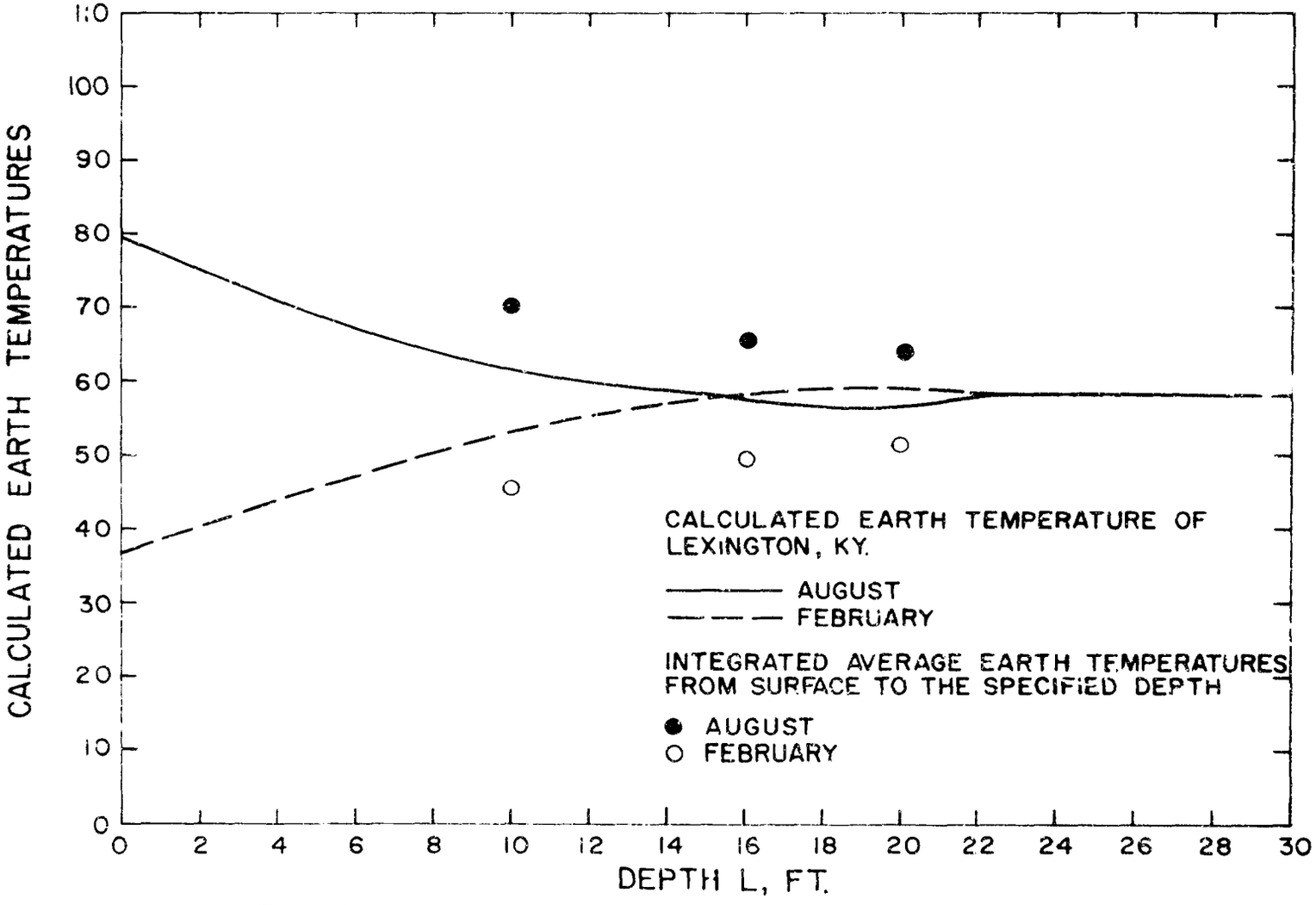

Figure 9 Calculated earth temperature and integrated depth average earth temperature plotted against depth from the surface in August and February for the station at Lexington, Kentucky

Thus, the maximum depth to be considered for contemporary shelter heat conduction analysis is approximately 20 ft from the surface. The earth temperatures studied in this report are, however, the monthly averages which will be considerably lower during the summer than the daily averages particularly near the surface. Thus, the integrated average temperature from surface to 10-ft depth, instead of 20-ft depth, is arbitrarily selected to represent a reasonable earth temperature criterion for protective shelter heat conduction. Fig. 9, however, shows that the average temperature of the upper 20 feet of earth is about 6 degrees lower than for the upper 10 feet of earth in the month of August for Lexington, Kentucky.

In studying summer shelter environment in the United States, integrated average August earth temperatures from surface to 10-ft depth are, therefore, of the greatest importance. On the other hand, it is also important to know the lower end of earth temperature cycle for the winter occupation of shelters, in which case the integrated February earth temperatures from the surface to 10-ft depth may be valuable. The maximum and minimum values of the integrated average earth temperatures of the upper 10-ft layer of earth are probably most useful from the standpoint of the underground shelter heat transfer analysis. Table 4 was, therefore, prepared to summarize annual maxima and minima of calculated 10-ft depth average earth temperatures for all of the earth temperature stations analyzed in this paper. Also listed in Table 4 are the annual maxima and minima of monthly average air temperatures observed at weather stations nearby the earth temperature

stations. The annual maxima and minima of the monthly average air temperature, however, occur for months of July and January, respectively, which are both one month ahead of the maxima and minima of earth temperatures. Although most of the air temperature data are based upon thirty years' norm (1921-1950), the earth temperature values in Table 4 are derived from records of only a few years' duration. Thus a good correlation between the annual maximum of the average earth temperature to maximum air temperature, or that between the minima, cannot be expected from these data.

Since all of the monthly earth temperatures in Table 4 and in Tables STA 1-63 have been calculated for the thermal diffusivity of 0.025 ft^2/hr, the computations were also made of the August earth temperature at five different thermal diffusivities for the purpose of comparison as shown in the lower part of Tables STA 1-63. It is interesting to note that the integrated averages of earth temperature for the upper 10 ft of earth are not greatly affected by the variation of earth thermal diffusivities. A diffusivity change from 0.02 ft^2/hr to 0.04 ft^2/hr, for instance, affects this integrated average earth temperature by approximately 2°F, whereas the same factor of 2 change in thermal diffusivity from 0.01 ft^2/hr to 0.02 ft^2/hr affects the integrated average temperature by 3°F to 4°F. Unless the soil is extremely dry or highly insulative, however, the in-situ earth thermal diffusivity is generally higher than 0.015 ft^2/hr, as seen from the values on Tables STA 1-63.

Table 4

Annual maxima and minima of air temperature and integrated average earth temperature from surface to 10-ft depth

ST No.	Earth Temp. Station	Air Temp. Station	Maximum		Minimum	
			Air [a]	Earth[b]	Air [a]	Earth[b]
1	Auburn, Ala.	Montgomery, Ala.	81	74	49	56
2	Decatur, Ala.	Huntsville, Ala.[d]	81	71	43	48
3	Tempe, Ariz.	Phoenix, Ariz.	90	81	50	59
4	Tucson, Ariz.	Tucson, Ariz.	86	85	50	65
5	Brawley, Calif.	Yuma, Ariz.	95	90	55	68
6	Davis, Calif.	Sacramento, Calif.	75	76	44	56
7	Ft. Collins, Colo.	Denver, Colo.	72	63	29	37
8	Ft. Collins, Colo.	Denver, Colo.	72	63	29	37
9	Ft. Collins, Colo.	Denver, Colo.	72	64	29	36
10	Gainesville, Fla.	Orlando, Fla.	82	80	62	69
11	Athens, Ga.	Athens, Ga.	81	77	45	57
12	Tifton, Ga.	Albany, Ga.	83	80	51	62
13	Moscow, Idaho	Idaho Falls, Idaho[e]	69	57	16	37
14	Argonne, Ill.	Chicago, Ill.	75	64	25	38
15	Lemont, Ill.	Chicago, Ill.	75	65	25	39
16	Urbana, Ill.	Springfield, Ill.	76	67	27	39
17	Urbana, Ill.	Springfield, Ill.	76	68	27	42
18	West Lafayette, Ind.	South Bend, Ind.	71	66	25	38
19	Burlington, Iowa	Burlington, Iowa[c]	77	71	24	38
20	Manhattan, Kans.	Concordia, Kans.	80	69	28	41
21	Lexington, Ky.	Lexington, Ky.	76	68	33	42
22	Lexington, Ky.	Lexington, Ky.	76	70	33	46
23	Upper Marlboro, Md.	Washington, D.C.	77	70	36	42
24	East Lansing, Mich.	East Lansing, Mich.[c]	71	63	24	37
25	East Lansing, Mich.	East Lansing, Mich.[c]	71	64	24	38
26	East Lansing, Mich.	East Lansing, Mich.[c]	71	63	24	37
27	East Lansing, Mich.	East Lansing, Mich.[c]	71	63	24	37
28	East Lansing, Mich.	East Lansing, Mich.[c]	71	63	24	37
29	St. Paul, Minn.	Minneapolis, Minn.	74	62	15	34
30	State Univ., Miss.	Meridian, Miss.	81	79	48	55
31	Faucett, Mo.	Springfield, Mo.	78	65	33	43
32	Kansas City, Mo.	Kansas City, Mo.	81	69	30	42
33	Sikeston, Mo.	Springfield, Mo.	78	71	33	43
34	Bozeman, Mont.	Billings, Mont.	73	56	23	33
35	Bozeman, Mont.	Billings, Mont.	73	56	23	32
36	Huntley, Mont.	Billings, Mont.	73	64	23	36
37	Lincoln, Nebr.	Lincoln, Nebr.	79	69	24	39
38	Lincoln, Nebr.	Lincoln, Nebr.	79	68	24	38
39	Norfolk, Nebr.	Norfolk, Nebr.	76	66	19	40
40	New Brunswick, N.J.	Newark, N.J.	75	65	32	42
41	Ithaca, N.Y.	Syracuse, N.Y.	73	59	26	39
42	Ithaca, N.Y.	Syracuse, N.Y.	73	59	26	39
43	Raleigh, N. Car.	Raleigh, N. Car.	79	73	41	52
44	Columbus, Ohio	Columbus, Ohio	74	65	30	41
45	Coshocton, Ohio	Columbus, Ohio	74	64	30	40
46	Barnsdall, Okla.	Oklahoma City, Okla.	82	74	37	54
47	Hominy, Okla.	Oklahoma City, Okla.	82	74	37	52
48	Lake Hefner, Okla.	Oklahoma City, Okla.	82	77	37	51
49	Pawhuska, Okla.	Oklahoma City, Okla.	82	74	37	50
50	Ottawa, Ont.	Ottawa, Ont.[f]	68	59	12	36
51	Corvallis, Oreg.	Eugene, Oreg.	77	66	38	46
52	Pendleton, Oreg.	Pendleton, Oreg.	75	67	31	39
53	Calhoun, S. Car.	Columbia, S. Car.	81	76	47	52
54	Union, S. Car.	Columbia, S. Car.	81	70	47	48
55	Madison, S. D.	Huron, S. D.[c]	75	61	14	33
56	Jackson, Tenn.	Oak Ridge, Tenn.	78	71	38	49
57	Temple, Texas	Waco, Texas	86	82	47	58
58	Temple, Texas	Waco, Texas	86	83	47	59
59	Salt Lake City, Utah	Salt Lake City, Utah	78	63	29	40
60	Burlington, Vt.	Burlington, Vt.	70	63	18	35
61	Pullman, Wash.	Walla Walla, Wash.[c]	76	60	32	36
62	Pullman, Wash.	Walla Walla, Wash.[c]	76	58	32	38
63	Seattle, Wash.	Seattle, Wash.	65	61	39	45

Remarks:

a. Unless otherwise stated, all the air temperature data are thirty year norm (1921-1950) airport data published in Technical Paper No. 31, U.S. Weather Bureau Publication 1956.

b. Earth temperatures shown are integrated average from surface to 10 ft depth calculated by observed earth temperature characteristics, each as average, amplitude and phase angle and earth thermal diffusivity of 0.025 ft^2/hr for most of the stations.

c. City office air temperature data instead of airport data.

d. Climatological Standard normals of 1931-1960 instead of 1921-1950 norm.

e. Exact location of air temperature station unknown.

f. Air temperature data from Penrod[9/]

Carter[18] shows extensive field records of temperature, moisture, and thermal properties of seven earth temperature and moisture measurement stations in the Tennessee Valley Area. Carter's data show that the field thermal diffusivities for various types of soil ranged from 0.016 ft^2/hr of clay to 0.045 ft^2/hr of clay-sand with the majority being in the neighborhodd of 0.025 ft^2/hr, with the moisture content of from 20 percent to 40 percent.

9. Conclusions

Extensive analyses have been made on earth temperature data from 63 stations located in fifty different areas throughout the United States. Annual cycles of monthly average earth temperatures have been used to study and correlate their annual averages, amplitudes, phase angles and thermal diffusivities.

It has been found that simplified heat conduction theory based upon the simple harmonic presentation of earth temperature provides an acceptable approximation of the monthly average earth temperatures at various depths. The thermal diffusivities computed by the amplitude and phase lag methods are in reasonably good agreement for most of the earth temperature data. The thermal diffusivities computed in these analyses from the data for Lexington, Kentucky, and Argonne, Illinois, are compatible with those computed by Penrod[8] and Carson,[10] respectively.

The tabulated data for the observed monthly average earth temperature for different localities can serve as a general guide in estimating earth temperatures in the vicinities of those particular stations. A monthly average earth temperature at a given point can be calculated by simple equation (3) if annual average earth temperature (A0), amplitude and phase angle of the ground surface temperature (B0), and (P0), and the thermal diffusivity are previously known. The influence of the thermal diffusivity upon the integrated average earth temperature to a depth of 10 ft is not too critical in that uncertainty by a factor of two in the diffusivity from 0.02 to 0.04 ft^2/hr produces only about 2°F change in average temperature for the month of August.

This analysis indicates that the annual average earth temperature in the range studied is invariant with respect to depth and is very closely approximated by the annual average air temperature or by Collin's ground water temperature map, shown in Fig. 1.

The temperature data analyzed in this report are, however, not extensive enough to provide a good statistical or functional correlation of ground surface temperature amplitude and the phase lag with respect to climatological and site characteristics of the earth temperature stations.

An adequate analysis of heat transfer in underground structures requires information on earth temperature distribution from the surface to a depth of about 10 ft. Very few of the data compiled in this report cover more than a 6-foot depth from the surface. The extensive calculation of earth temperatures for depths of 2, 4, 6, 8 and 10 ft and the integrated depth average for all of the earth temperature stations employed in this paper have been based on the temperature characteristics derived from the observed monthly average earth temperatures and selected thermal diffusivity of 0.025 ft^2/hr. Annual maxima and minima of the upper 10-ft earth temperature are summarized in Table 6 of this paper. Until more comprehensive and substantial data are made available in the future, the values of Table 6 may serve as tentative design criteria for analyzing the heat transfer of underground structures.

10. Recommendations:

Although a considerable amount of earth temperature data have been compiled during this study, deep earth temperature data (to the depth of more than 3 ft) are conspicuously missing from most of the southern and western states as seen from Fig. 1. Establishment of new earth temperature stations in these regions is clearly needed.

The following suggestions should be considered in selecting earth temperature stations for future studies related to the design requirements for shelters:

(1) Earth temperature sites should be close to local weather stations where simultaneous observations of air temperature, rainfall, solar radiation and other pertinent records are kept.

(2) Earth should be bare or covered with short grass. If possible, two sites should be chosen at the same relative location; one grass-covered and one bare.

(3) Soil composition and dry density should be determined and the moisture content should be checked at intervals during the period of study.

(4) Enough observations should be taken during the day to obtain a good daily average temperature, particularly at depths less than 3 ft.

(5) At least three years of continuous data are needed.

(6) Temperatures should be observed at five or more depths, at least three of which should be in excess of 5 ft.

11. Appendix: Discussion of Least-Squares Technique

Numerous papers are available with respect to the calculation of earth temperature. Recent papers of Penrod,[8,9] Carson,[10] and Langbein[11] are, however, noteworthy from the standpoint of their distinctly different approaches. Penrod[9] developed equations of a single harmonic term to describe the annual ground temperature cycles of Lexington, Kentucky, and Ottawa, Ontario. Carson[10] described the hourly and monthly earth temperatures of Argonne, Illinois, by a Fourier series of six harmonics.

Langbein[11] has shown a method of predicting the earth temperature at a point as a weighted function of antecedent temperatures at the ground surface using the probability integral function.

Examination of Carson's work[10] reveals that as much as 99.8 and as little as 93% of the total variance of the annual cycle are accounted for by the first harmonic. In this paper, therefore, equations of simple harmonics of the following type have been developed to describe the monthly earth temperature at several depths using a least-squares fitting technique:

$$t = A - B \cos (\omega\theta - P) \qquad \text{A-1}$$

where t = monthly average ground temperature at a point for a given time

A = annual average earth temperature, °F

B = annual amplitude of the earth temperature, °F, at a given depth

ω = angular velocity corresponding to the annual cycle, radian/hr

θ = elapsed time from January 1, hr

P = phase angle of the earth temperature at a given depth, radian

The values of A, B, and P have been so determined in this analysis that the following least-squares relationship has been satisfied:

$$S = \sum_{K=1}^{N} (t - t_K)^2 \rightarrow \text{minimum} \qquad \text{A-2}$$

where t_K = observed earth temperature at a given point and for a given time

and N = total number of observed data at a given point

The standard deviation of the least-squares fit values from the observed temperatures is designated and calculated by the following relation:

$$SD = \sqrt{\frac{S}{N-3}} \qquad \text{A-3}$$

Any time series, such as earth temperature data, consisting of a finite number of equally spaced data points can be completely accounted for by a finite number of sine and cosine terms in a Fourier Analysis. This was done exactly by Carson[10] for the analysis of a monthly average and daily average earth temperature series consisting, respectively, of 12 and 24 equally spaced data points in Argonne, Illinois. An examination of Carson's results indicates that the higher harmonics of Fourier series have a very minor contribution to the description of the annual cycle for all the depths. It should be noted, however, that the higher harmonics show a considerable influence upon the diurnal earth temperature equations for all the depths, regardless of the time of year. Since the annual variation of the monthly average temperature is of a greater interest than the diurnal variation for the purpose of shelter design, the use of the higher harmonics is not warranted. It is hypothesized therewith that any deviation of monthly average soil temperature data from simple harmonic time function is statistical rather than functional. And it is also assumed that the constants A, B, and P of equation A-1 for a given temperature point are independent of the year when the data are taken; namely, they are the intrinsic properties of the particular point.

One of the purposes of this study is then the determination of A, B, and P at several depths of earth for many soil stations throughout the United States. Compared with the technique employed by Penrod[9] for the determination of B and P, the least squares technique developed here is fundamentally more straightforward, simpler, and requires no human judgment. The method is better suited for a machine calculation.

The comparison of the least squares technique with the Fourier analysis or harmonic analysis technique is most interesting. Such discussion is, however, beyond the scope of this report except that the Fourier analysis uses the earth temperature data as time dependent variables (single valued), whereas the least squares technique uses the earth temperature data as time dependent variates which are random in nature and multi-valued.

The Langbein technique[14] is of different nature and beyond the scope of this discussion.

Using the symbols listed in the Nomenclature section of this report, a quantity S, is defined by relation A-2 such that

$$S = \sum_{K=1}^{N} \left(t_K - A + B \cos (\omega_K - P) \right)^2 \qquad \text{A-4}$$

where N does not have to be 12 or its multiples. A, B, and P are determined by solving simultaneously the following equations

$$\frac{\partial S}{\partial A} = 0$$

$$\frac{\partial S}{\partial B} = 0 \qquad \text{A-5}$$

$$\frac{\partial S}{\partial P} = 0$$

The following notations are now introduced:

$$\alpha_o = \Sigma\, t_K$$

$$\alpha_1 = \Sigma\, t_K \cos \omega_K$$

$$\alpha_2 = \Sigma\, t_K \sin \omega_K$$

$$\xi_1 = \Sigma \cos \omega_K$$

$$\xi_2 = \Sigma \sin \omega_K \qquad \text{A-6}$$

$$\xi_3 = \Sigma \cos^2 \omega_K$$

$$\xi_4 = \Sigma \sin^2 \omega_K$$

$$\xi_5 = \Sigma \sin \omega_K \cos \omega_K$$

Relations A-2 become then

$$\alpha_o - NA + B\,(\xi_1 \cos P + \xi_2 \sin P) = 0$$

$$(\alpha_1 - A\xi_1)\cos P + (\alpha_2 - A\xi_2)\sin P$$

$$= -B\,(\xi_3 \cos^2 P + \xi_4 \sin^2 P + \xi_5 \sin 2P) \qquad \text{A-7}$$

$$(\alpha_1 - A\xi_1)\sin P - (\alpha_2 - A\xi_2)\cos P$$

$$= B\left\{\xi_5 \cos 2P - (\xi_3 - \xi_4)\sin P \cos P\right\}$$

By noting that

$$\xi_1 = \xi_2 = 0$$

$$\xi_3 = \xi_4 = \frac{N}{2} \quad \text{when } \theta_K = \frac{K-1}{N}\,T,\ K = 1,2,\ldots..N \qquad \text{A-8}$$

$$\xi_5 = 0$$

where T = period of the cyclic data, one obtains

$$A = \frac{\Sigma t_K}{N}$$

$$B = -\frac{2}{N}\sqrt{(\Sigma\, t_K \cos \omega\theta_K)^2 + (\Sigma\, t_K \sin \omega\theta_K)^2}$$

and

$$P = \tan^{-1}\frac{\Sigma\, t_K \sin \omega\theta_K}{\Sigma\, t_K \cos \omega\theta_K} \qquad \text{A-9}$$

An advantage of the least squares technique employed in this analysis is that it does not require conditions A-8. Thus, the earth temperature observation for certain months could be completely missing whereas some other months may have several observations. Although the determination of A, B and P for this procedure is much more complicated than those expressed by A-9, an iterative solution of A-7 is readily obtained by an electronic computer.

The iterative solution of A-7 is actually unnecessary if the expression of A-4 is modified so that the normalized least squares equation A-5 are all made linear with respect to linearized variables.

It is also possible to add one more partial derivative term such $\frac{\partial S}{\partial D} = 0$ to A-5 and solve it together with the rest of the linear normal equations. In this way it is possible to find a single (not two) thermal diffusivity that will satisfy the least squares requirement together with other least squares constants such as A, B and P.

Further work is in progress along this line and will be discussed in a forthcoming report.

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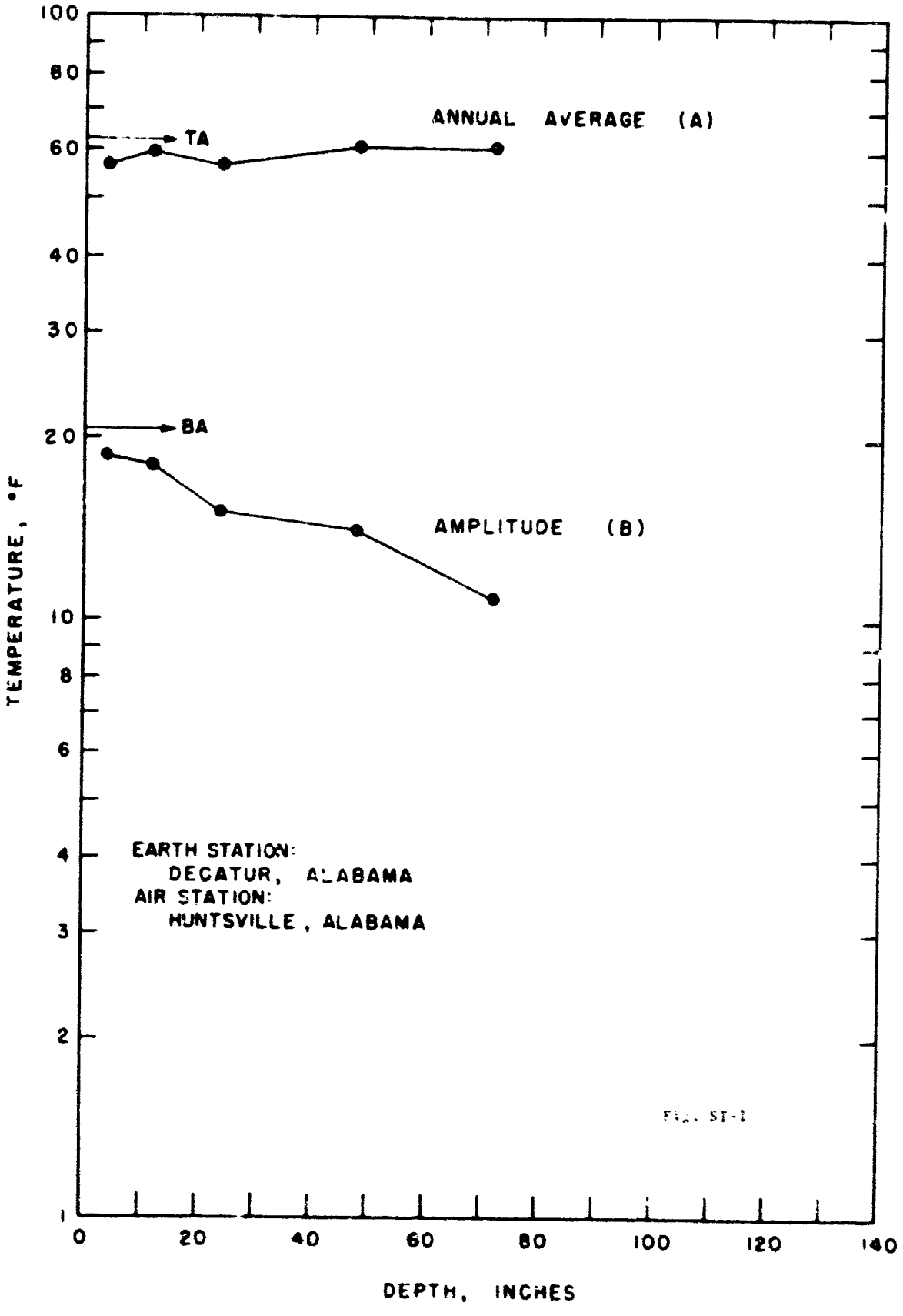
Figures ST-1 to ST-19	Annual average earth temperature and amplitude plotted against depth
Figures SP-1 to SP-19	Earth temperature phase angle plotted against depth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AMPLITUDE (B)
EARTH STATION:
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AIR STATION:
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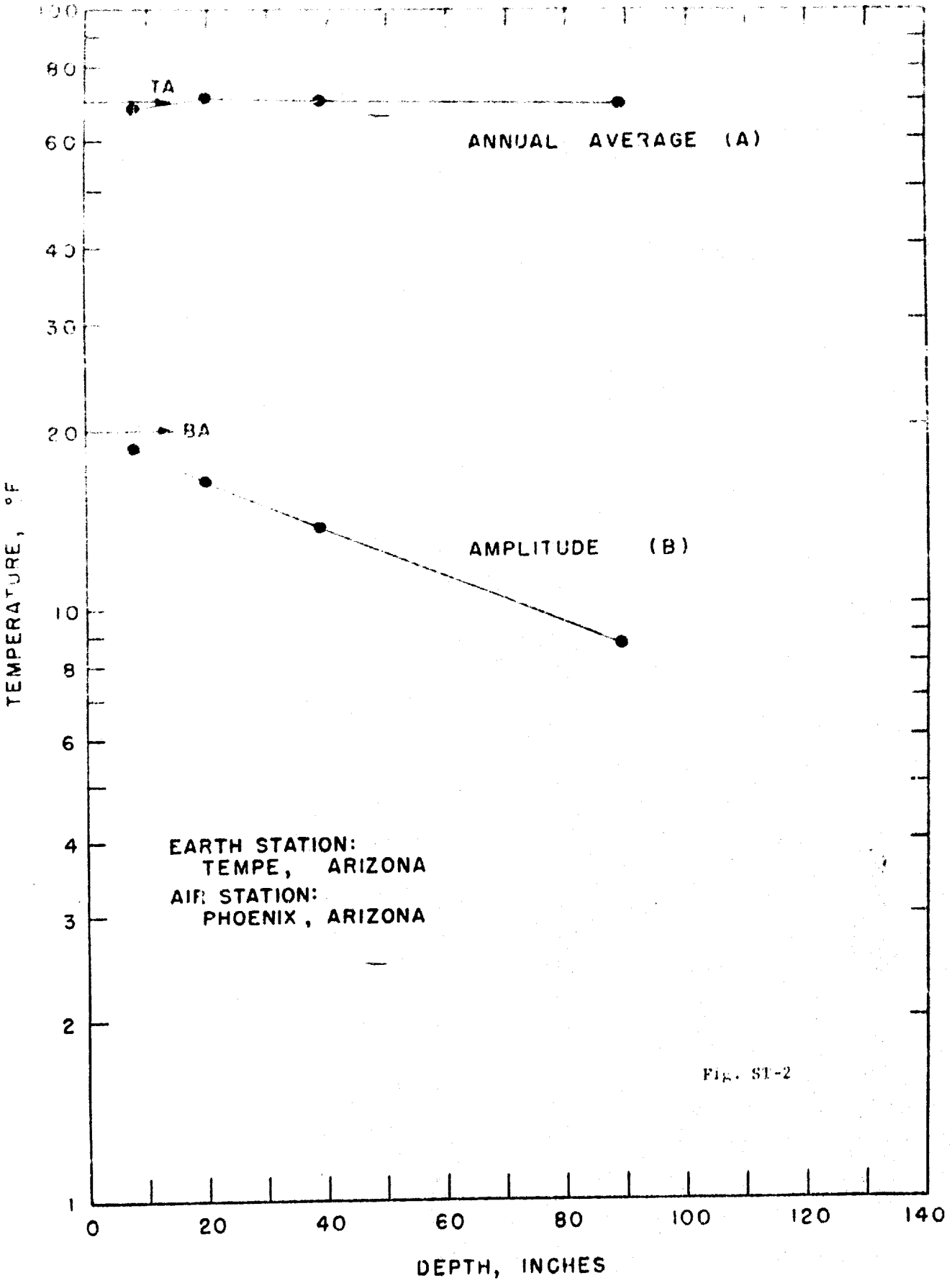
DEPTH, INCHES

Fig. ST-1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TEMPERATURE, °F
EARTH STATION:
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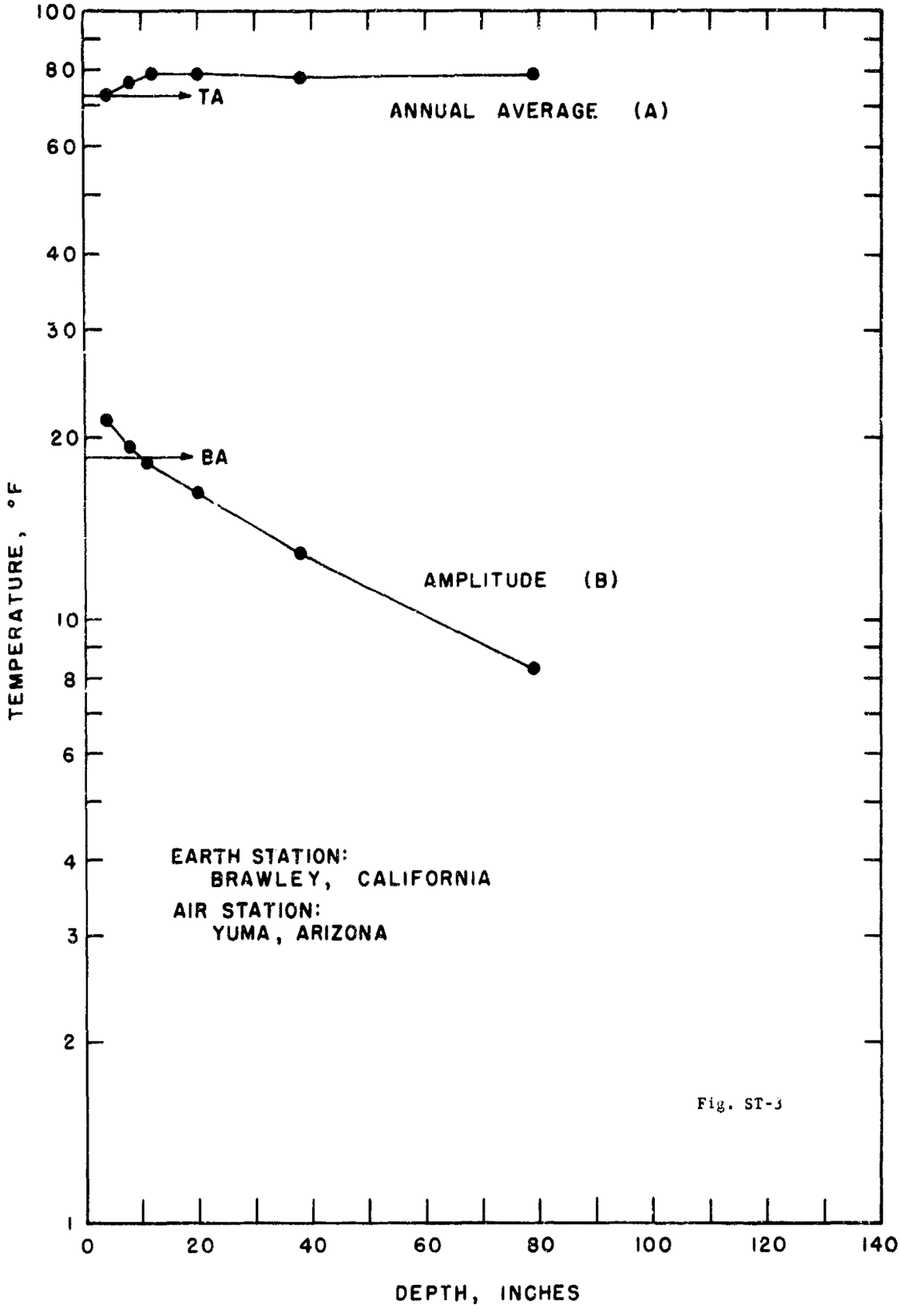
Fig. S1-2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TEMPERATURE, °F
EARTH STATION:
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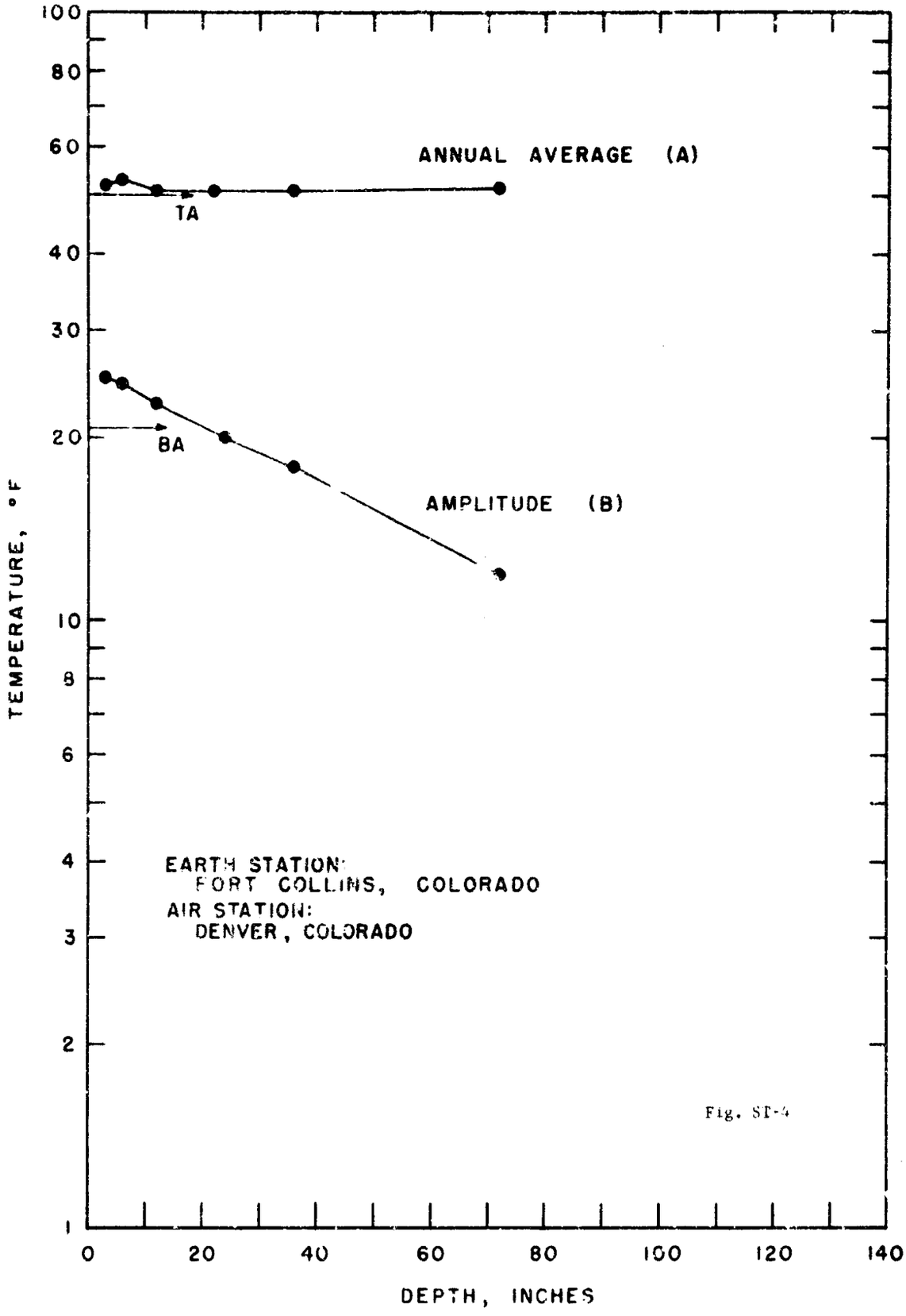
Fig. ST-3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AMPLITUDE (B)
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FORT COLLINS, COLORADO
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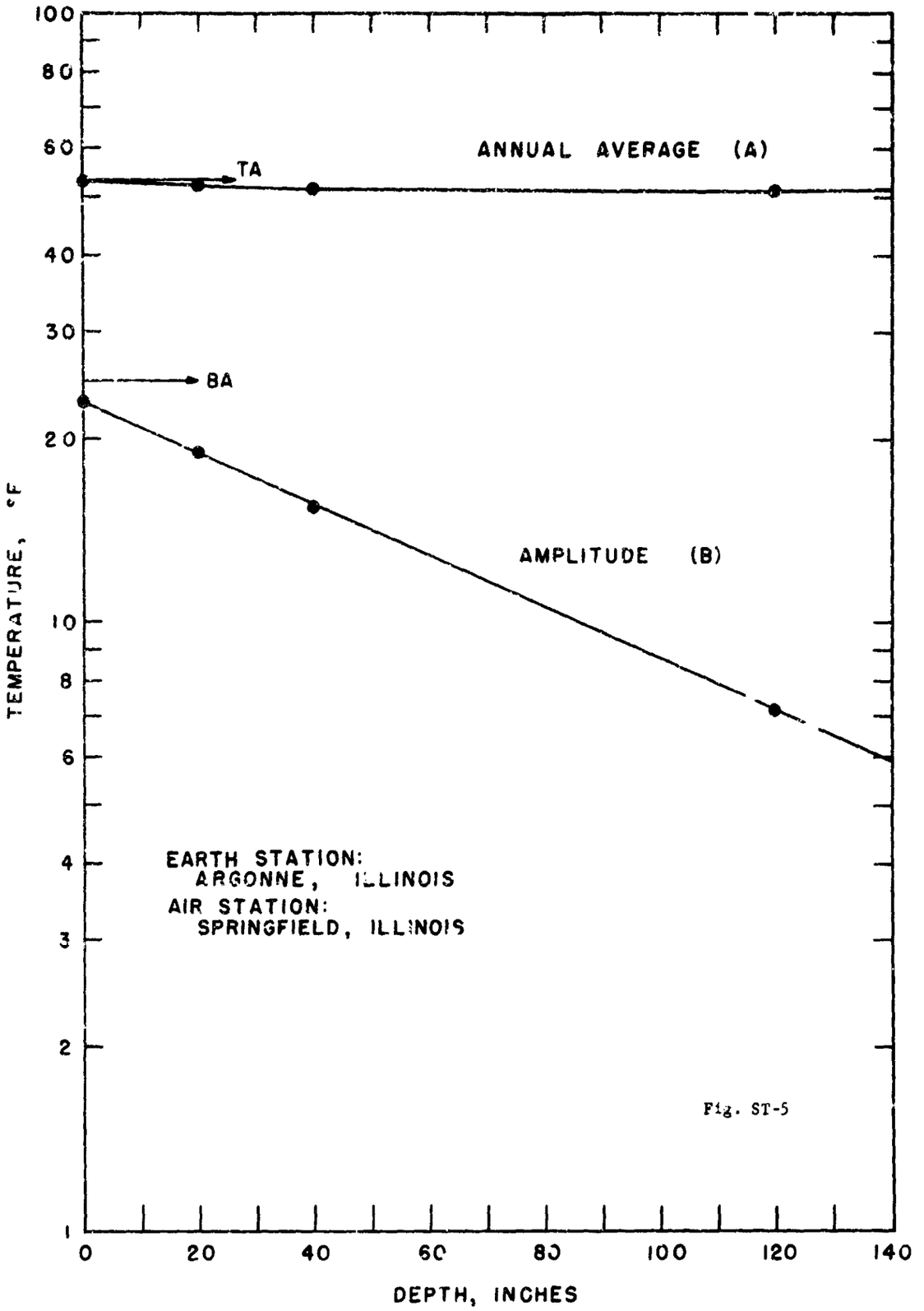
DEPTH, INCHES

Fig. ST-4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AMPLITUDE (B)
EARTH STATION:
ARGONNE, ILLINOIS
AIR STATION:
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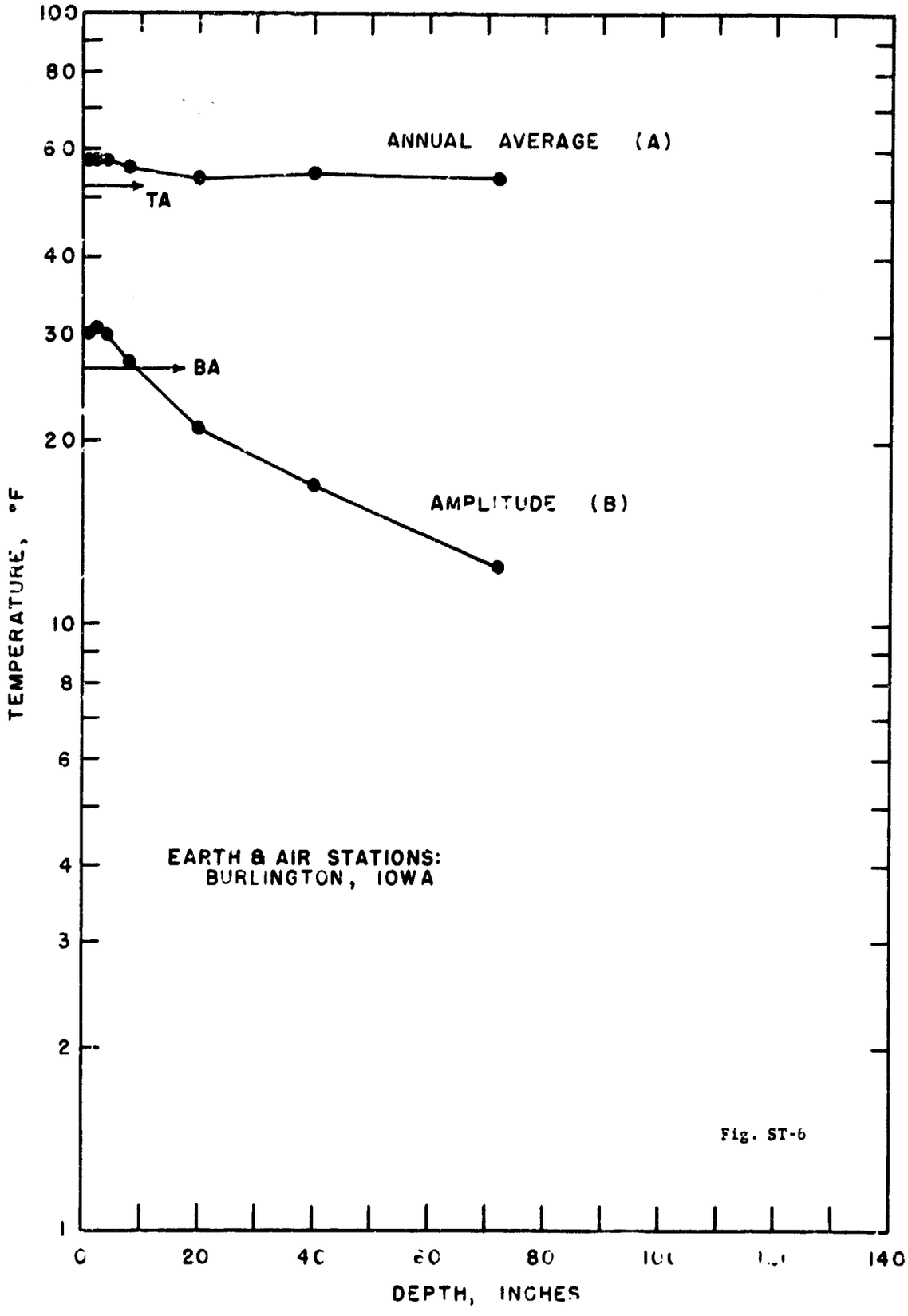
DEPTH, INCHES

Fig. ST-5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AMPLITUDE (B)
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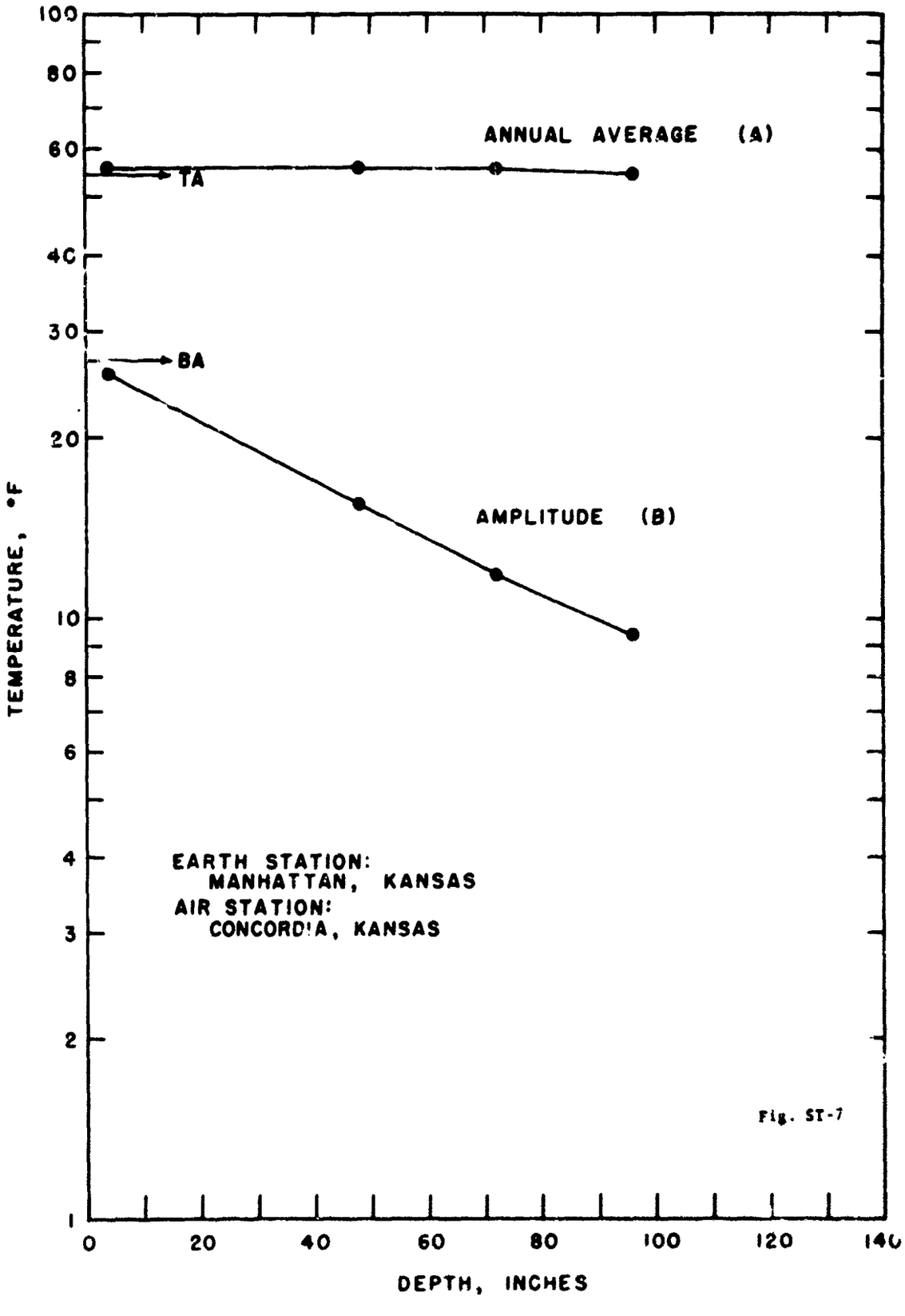
DEPTH, INCHES

Fig. ST-6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AMPLITUDE (B)
EARTH STATION:
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AIR STATION:
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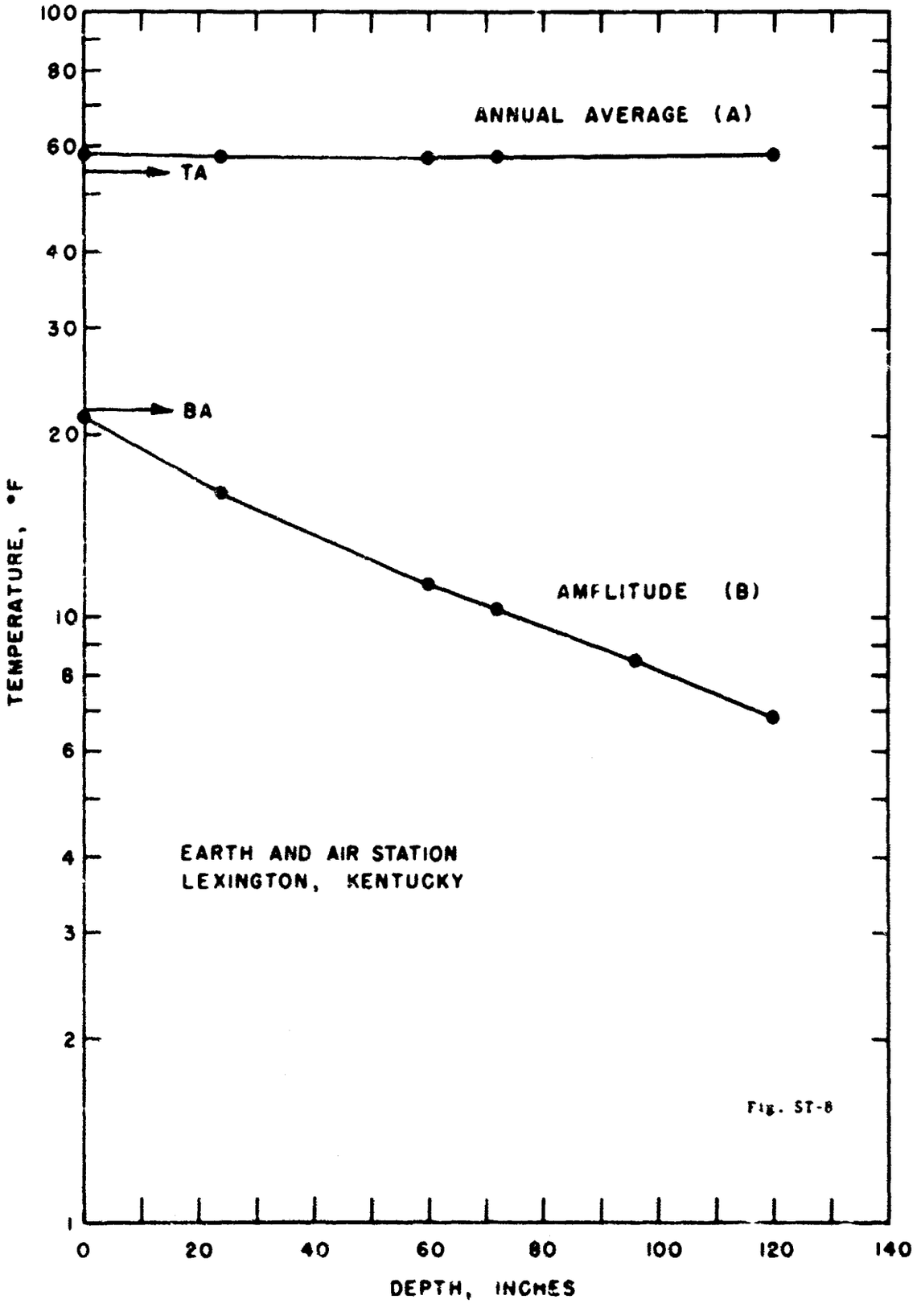
DEPTH, INCHES

Fig. ST-7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ANNUAL AVERAGE (A)
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AMPLITUDE (B)
EARTH AND AIR STATION
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Fig. ST-8
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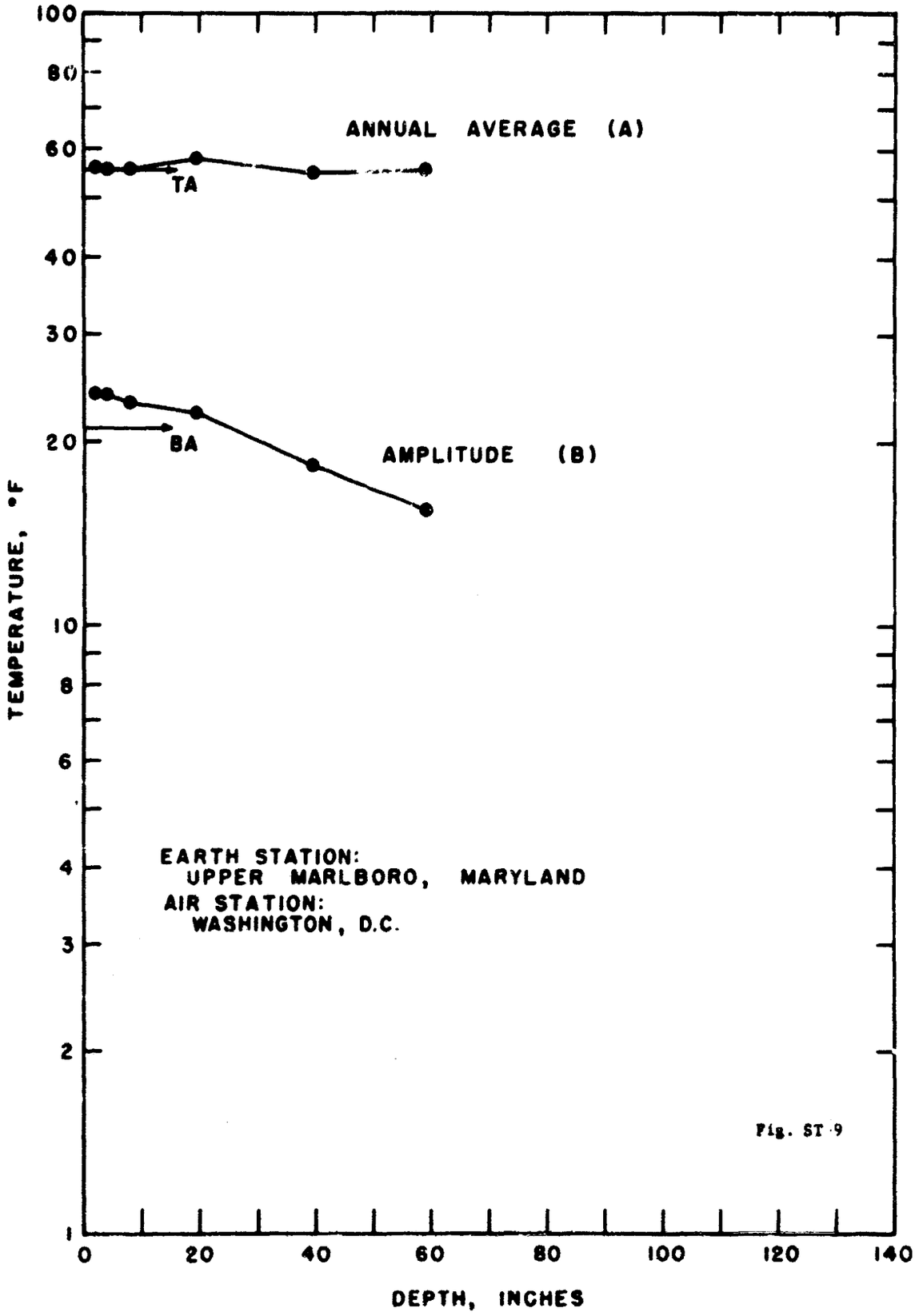
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TA
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AMPLITUDE (B)
EARTH STATION:
UPPER MARLBORO, MARYLAND
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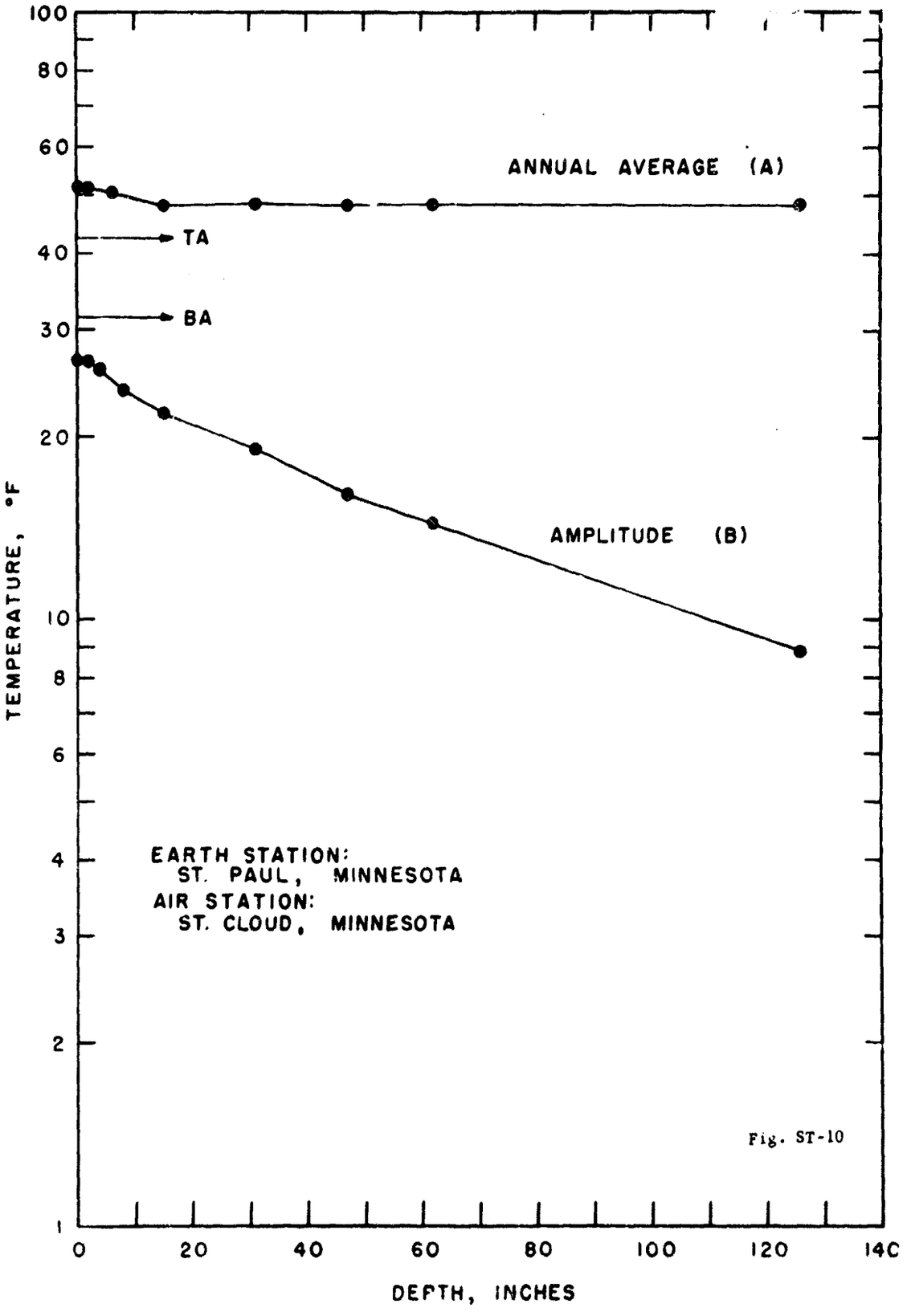
DEPTH, INCHES

Fig. ST-9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AMPLITUDE (B)
EARTH STATION:
ST. PAUL, MINNESOTA
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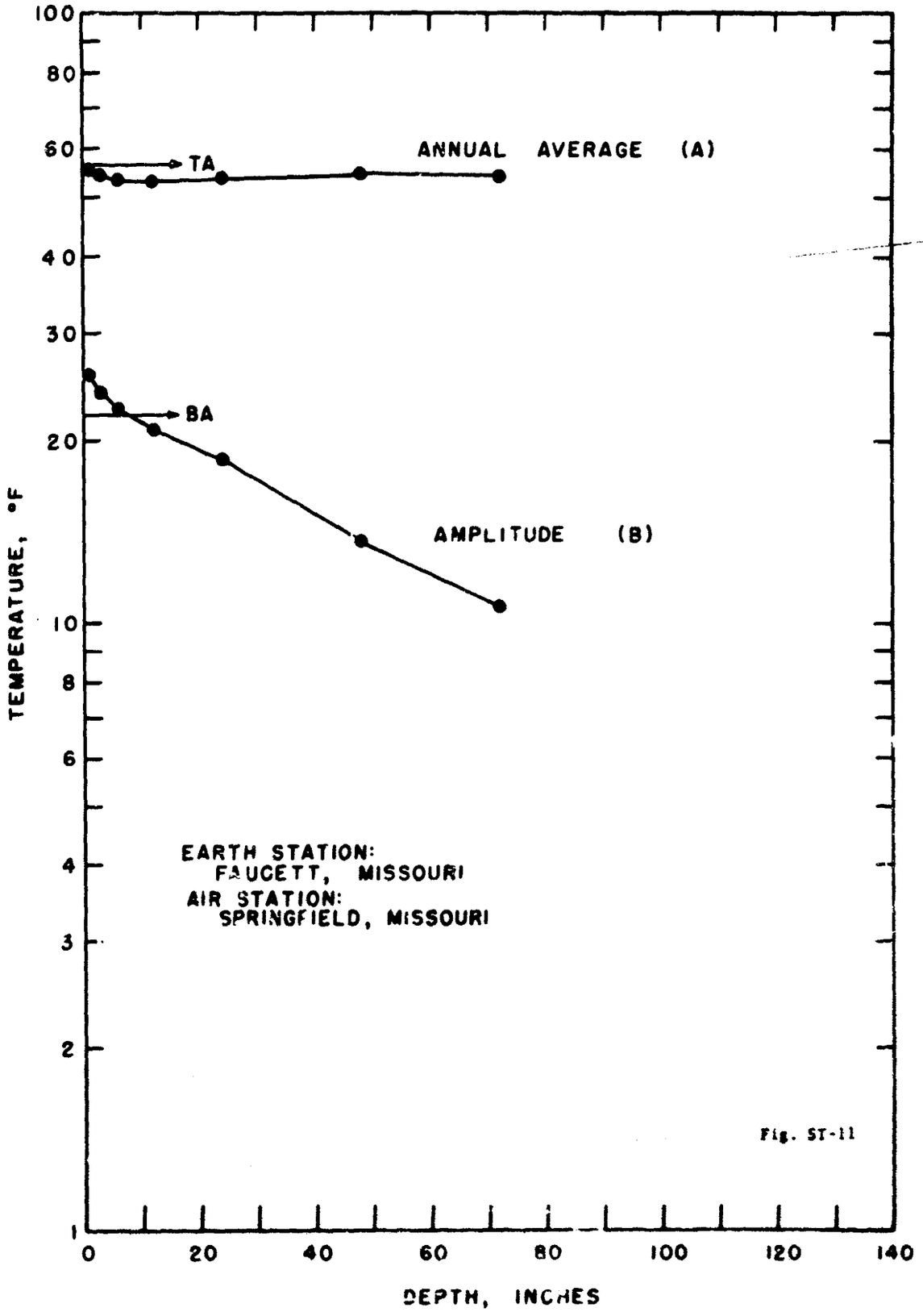
Fig. ST-10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EARTH STATION:
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Fig. ST-11
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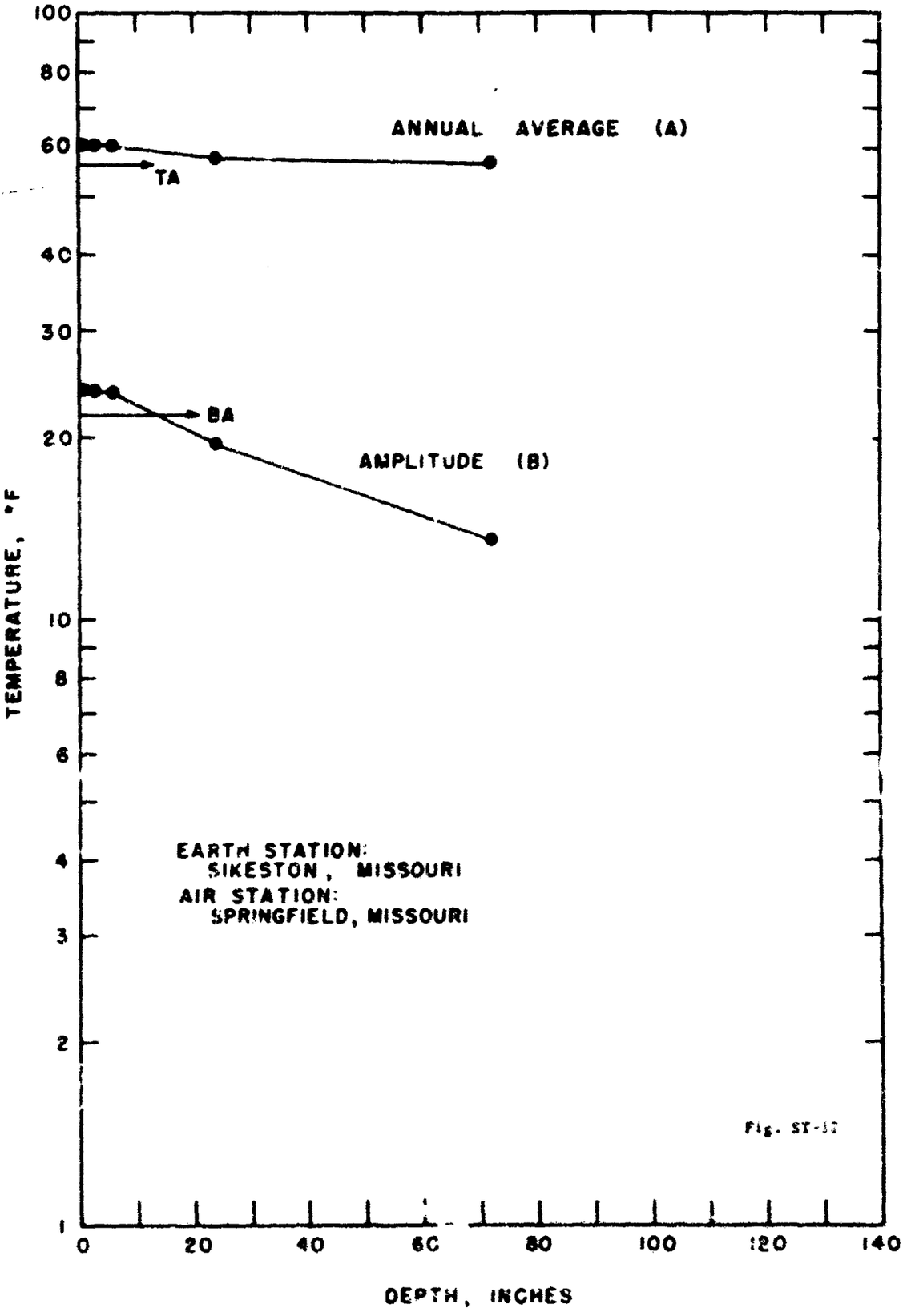
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TEMPERATURE, °F
EARTH STATION:
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Fig. ST-[illegible]

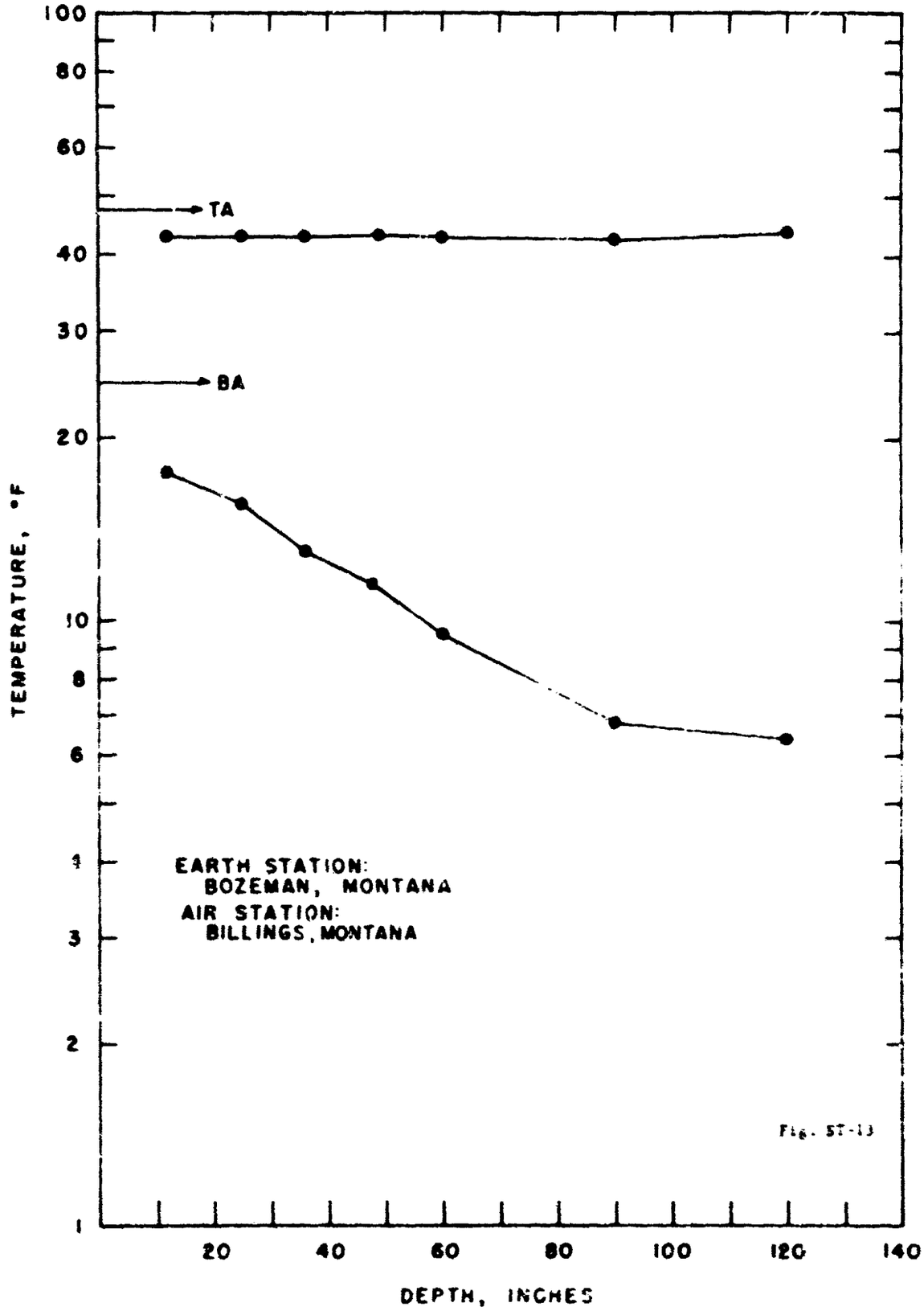
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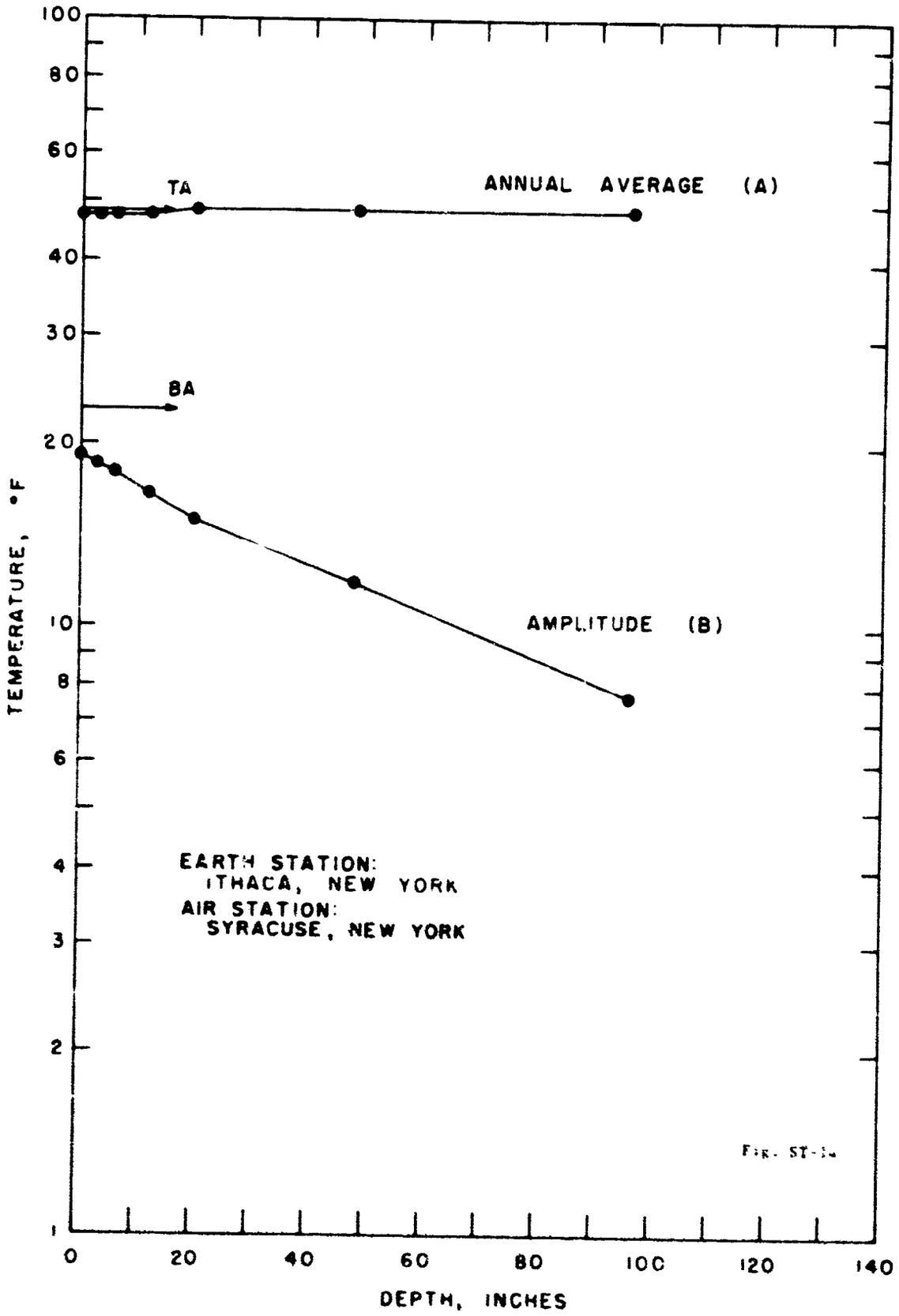
Fig. ST-13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AMPLITUDE (B)
EARTH STATION:
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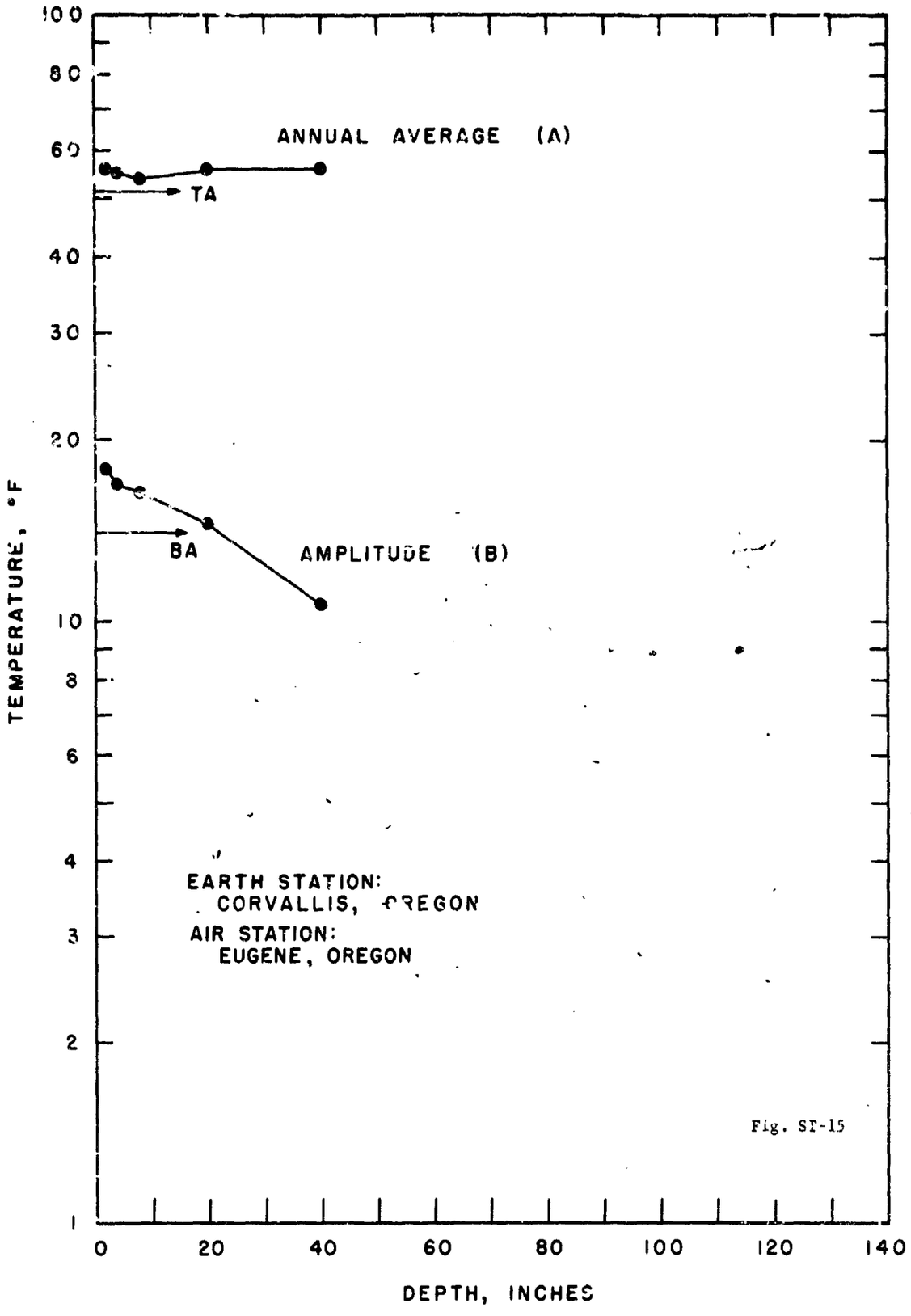
DEPTH, INCHES

FIG. ST-14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TEMPERATURE, °F
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AMPLITUDE (B)
EARTH STATION:
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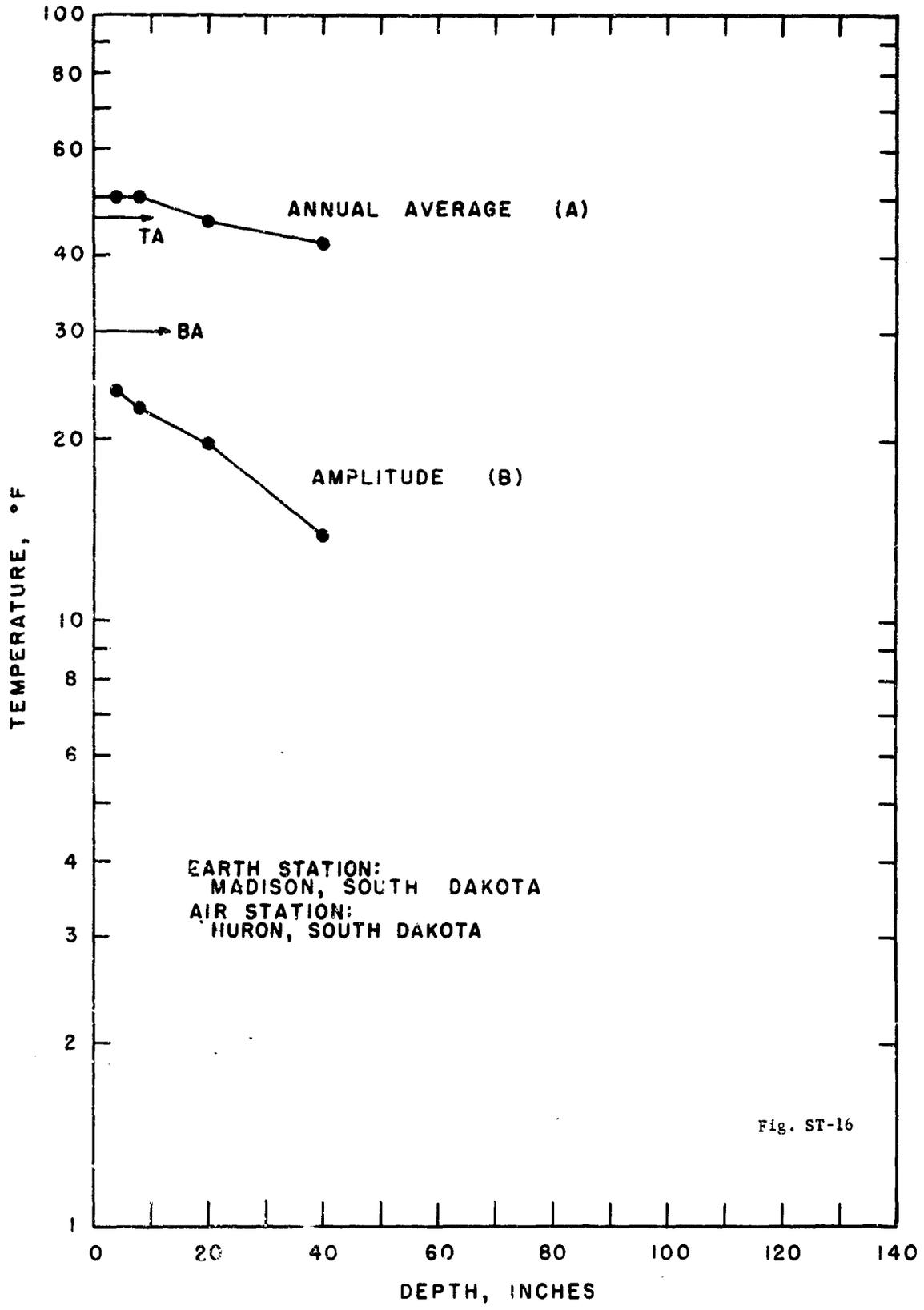
DEPTH, INCHES

Fig. ST-15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4
3
2
1
TEMPERATURE, °F
ANNUAL AVERAGE (A)
TA
BA
AMPLITUDE (B)
EARTH STATION:
MADISON, SOUTH DAKOTA
AIR STATION:
HURON, SOUTH DAKOTA
0
20
40
60
80
100
120
140
DEPTH, INCHES

Fig. ST-16

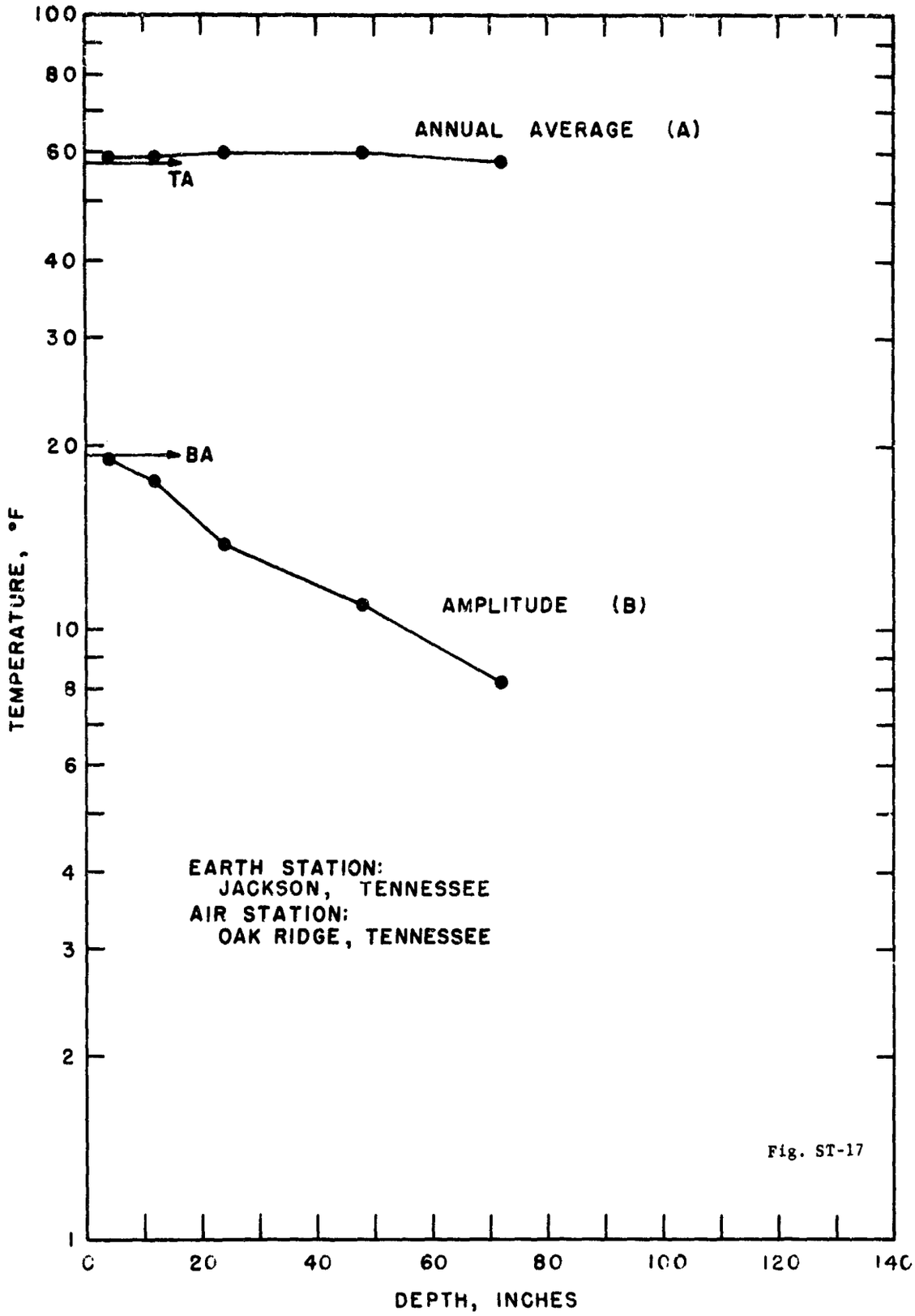

100
80
60
40
30
20
10
8
6
4
3
2
1
TEMPERATURE, °F
ANNUAL AVERAGE (A)
TA
BA
AMPLITUDE (B)
EARTH STATION:
JACKSON, TENNESSEE
AIR STATION:
OAK RIDGE, TENNESSEE
0
20
40
60
80
100
120
140
DEPTH, INCHES

Fig. ST-17

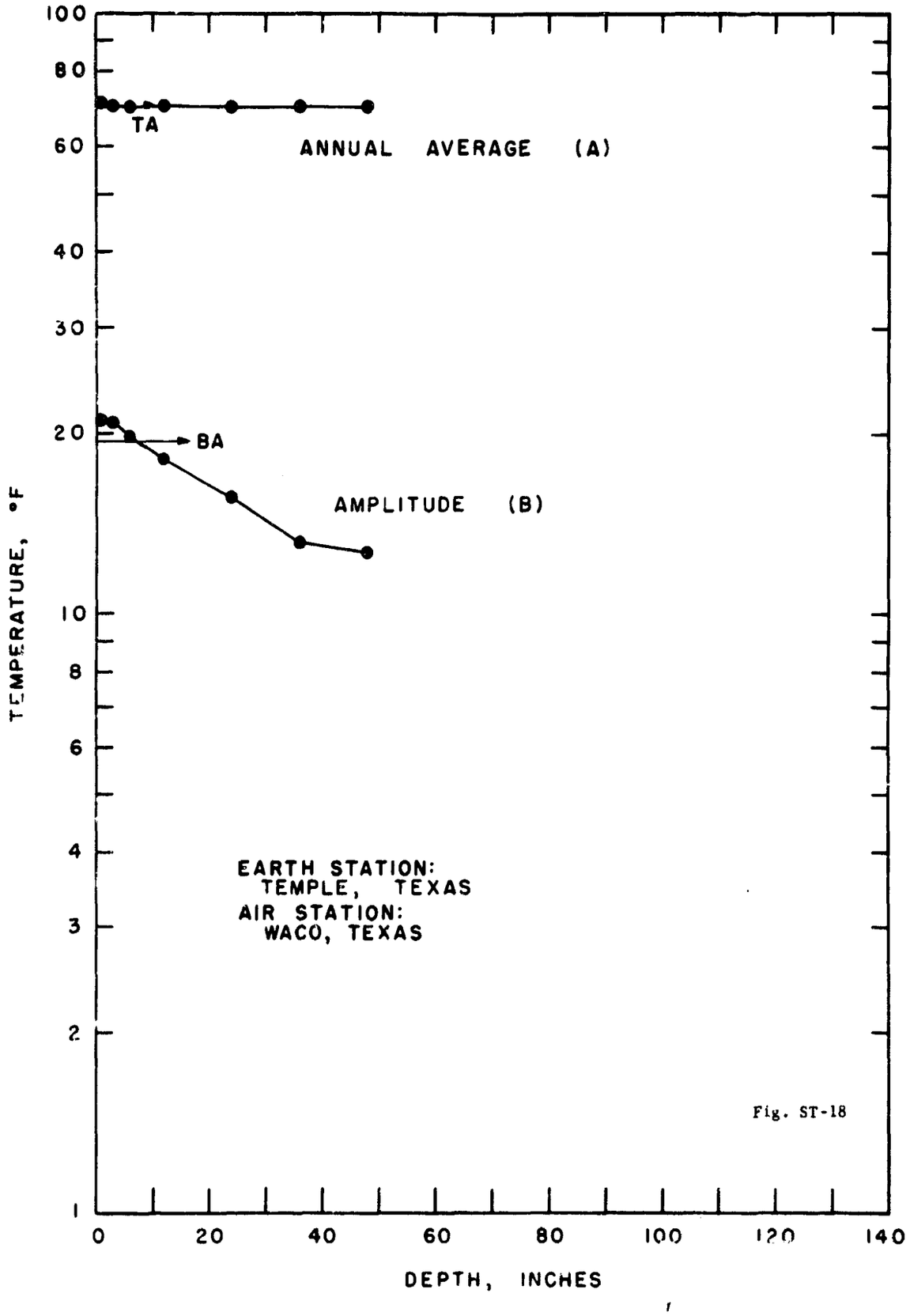

100
80
60
40
30
20
10
8
6
4
3
2
1
TA
ANNUAL AVERAGE (A)
BA
AMPLITUDE (B)
TEMPERATURE, °F
EARTH STATION:
TEMPLE, TEXAS
AIR STATION:
WACO, TEXAS
0
20
40
60
80
100
120
140
DEPTH, INCHES

Fig. ST-18

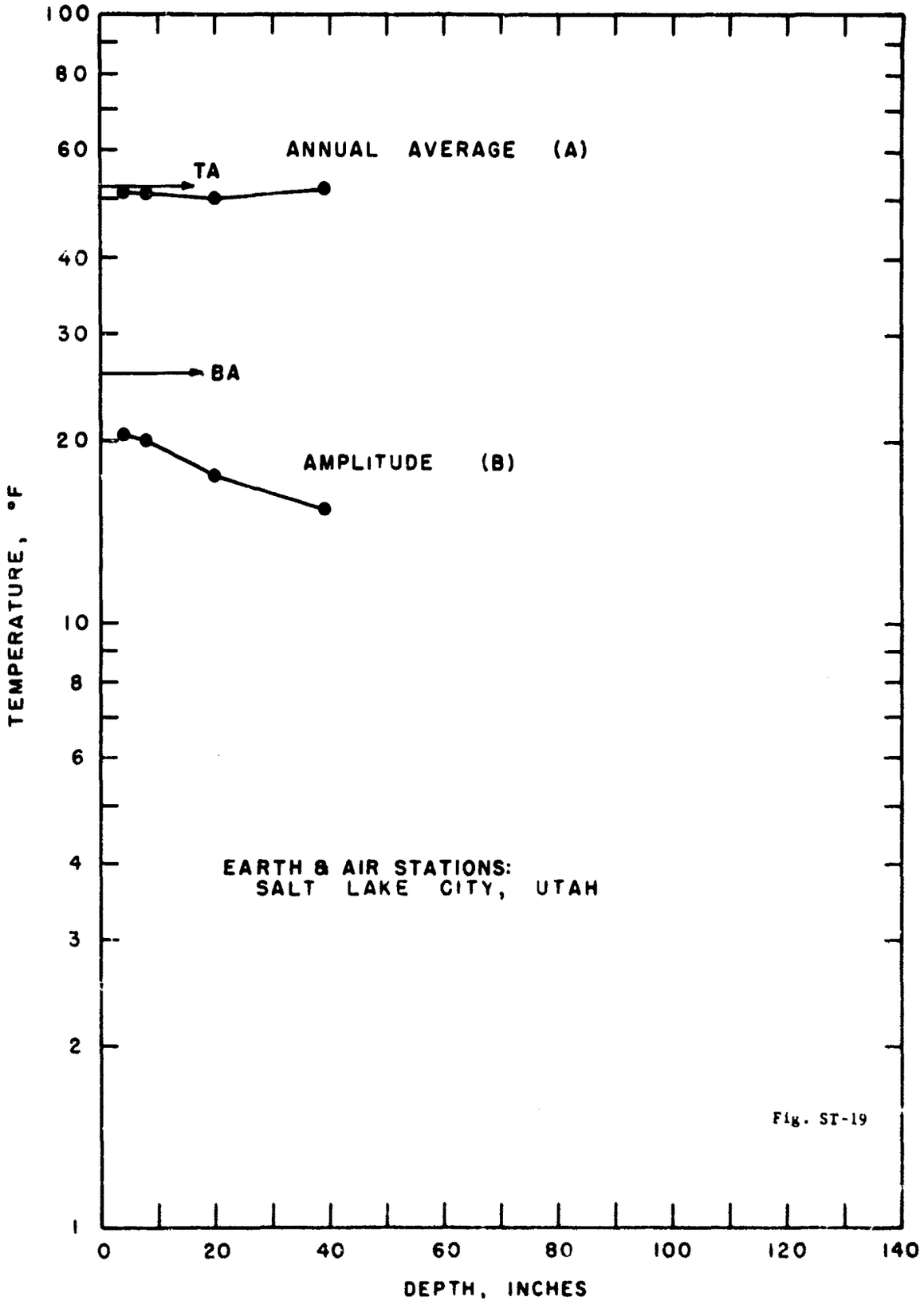

100
80
60
40
30
20
10
8
6
4
3
2
1
TEMPERATURE, °F
ANNUAL AVERAGE (A)
TA
BA
AMPLITUDE (B)
EARTH & AIR STATIONS:
SALT LAKE CITY, UTAH
0
20
40
60
80
100
120
140
DEPTH, INCHES

Fig. ST-19

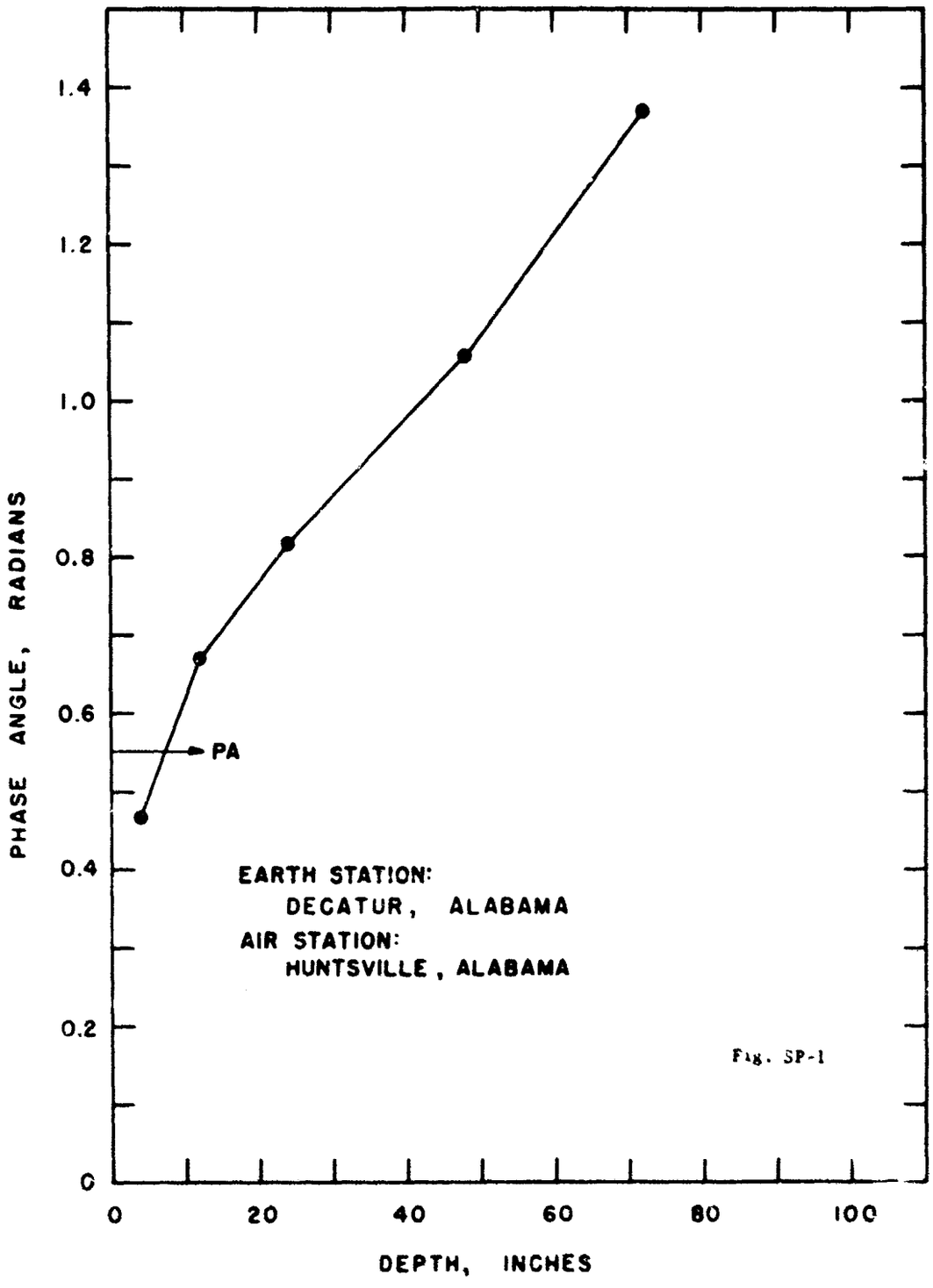

1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
PHASE ANGLE, RADIANS
PA
EARTH STATION:
DECATUR, ALABAMA
AIR STATION:
HUNTSVILLE, ALABAMA
0
20
40
60
80
100
DEPTH, INCHES

Fig. SP-1

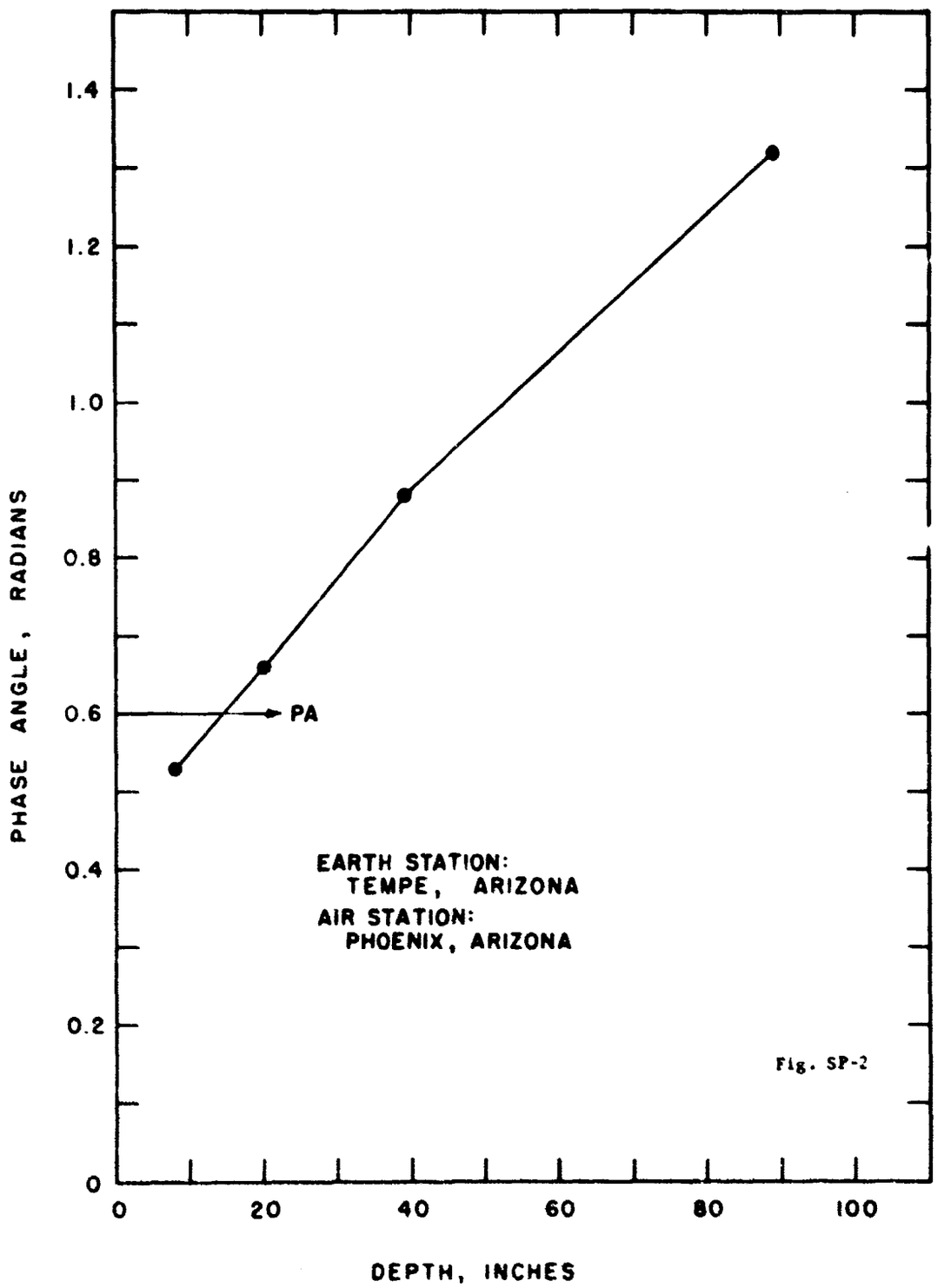

1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
PHASE ANGLE, RADIANS
PA
EARTH STATION:
TEMPE, ARIZONA
AIR STATION:
PHOENIX, ARIZONA
0
20
40
60
80
100
DEPTH, INCHES

Fig. SP-2

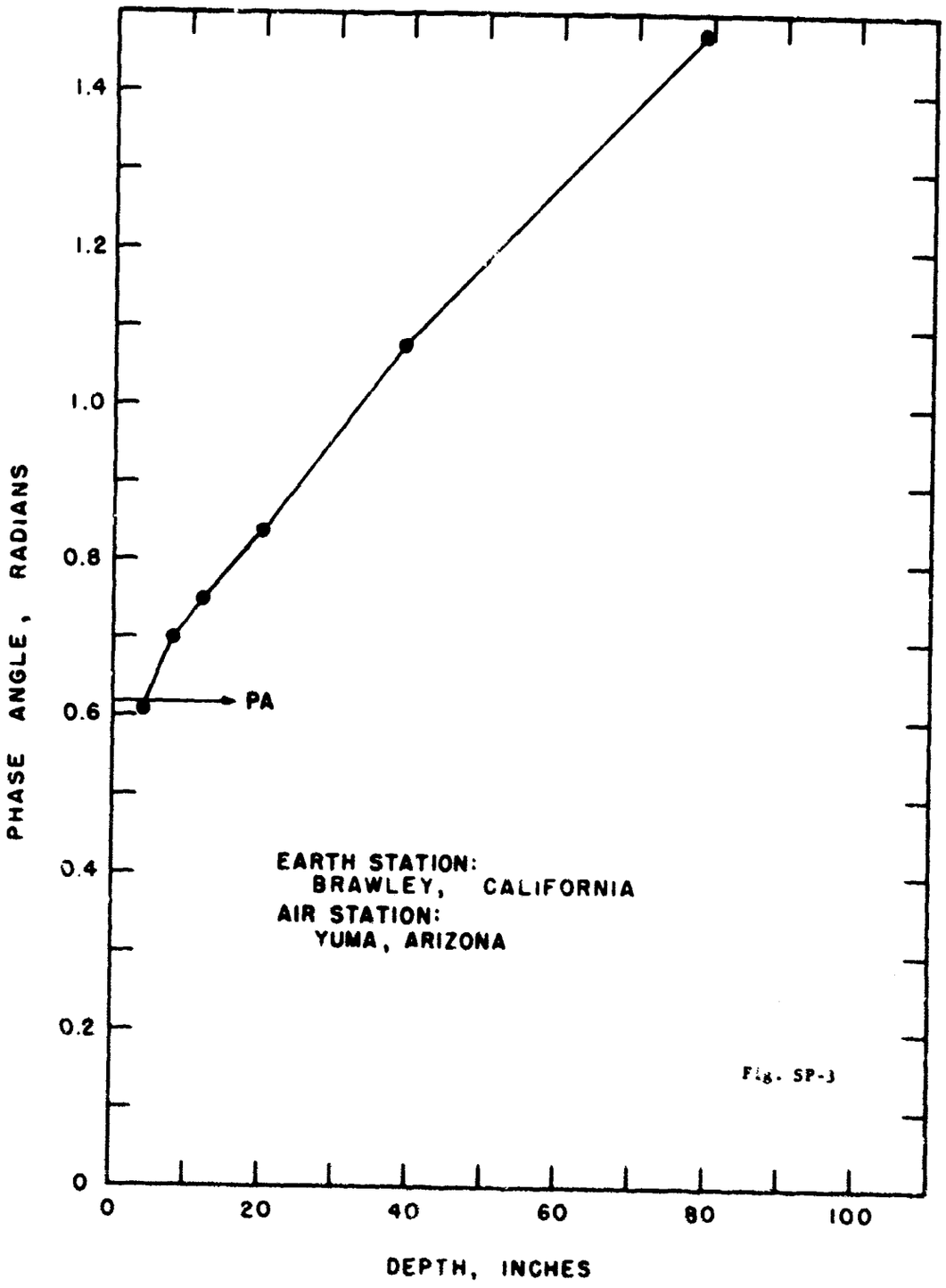

PHASE ANGLE, RADIANS
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
PA
EARTH STATION:
BRAWLEY, CALIFORNIA
AIR STATION:
YUMA, ARIZONA
0
20
40
60
80
100
DEPTH, INCHES

Fig. SP-3

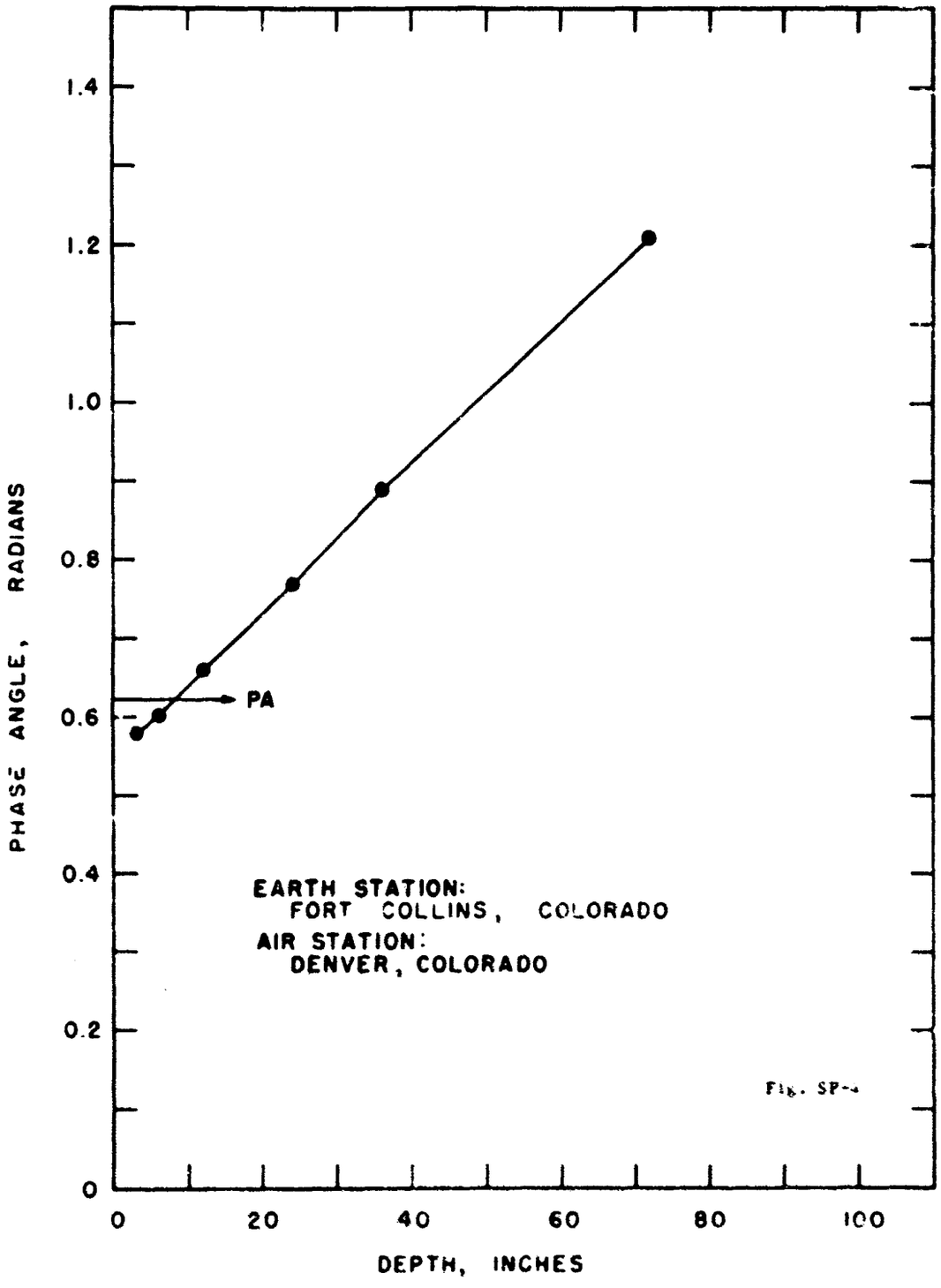

1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
PHASE ANGLE, RADIANS
PA
EARTH STATION:
FORT COLLINS, COLORADO
AIR STATION:
DENVER, COLORADO
0
20
40
60
80
100
DEPTH, INCHES

Fig. SP-4

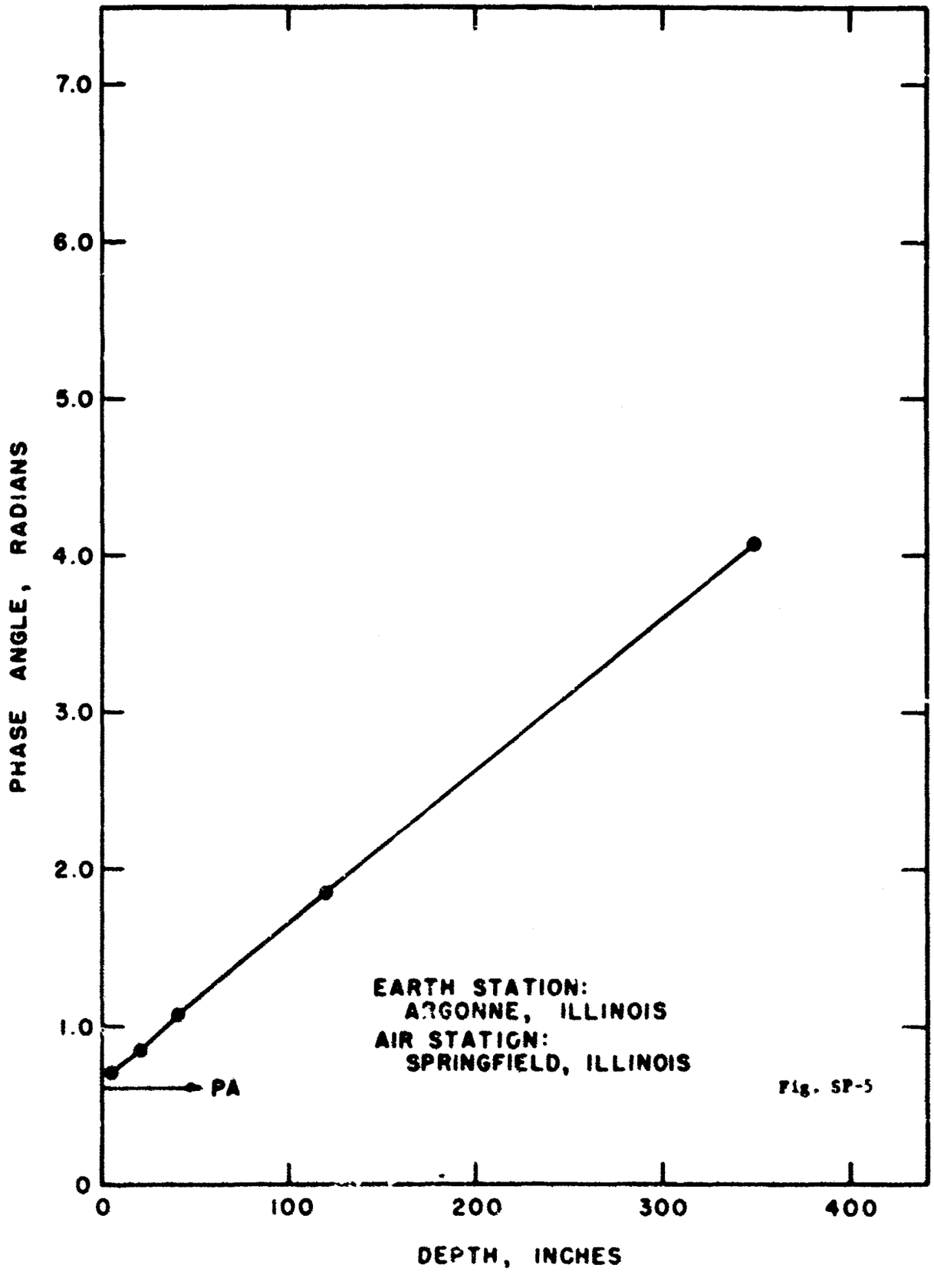

7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
PHASE ANGLE, RADIANS
0
100
200
300
400
DEPTH, INCHES
PA
EARTH STATION:
ARGONNE, ILLINOIS
AIR STATION:
SPRINGFIELD, ILLINOIS

Fig. SP-5

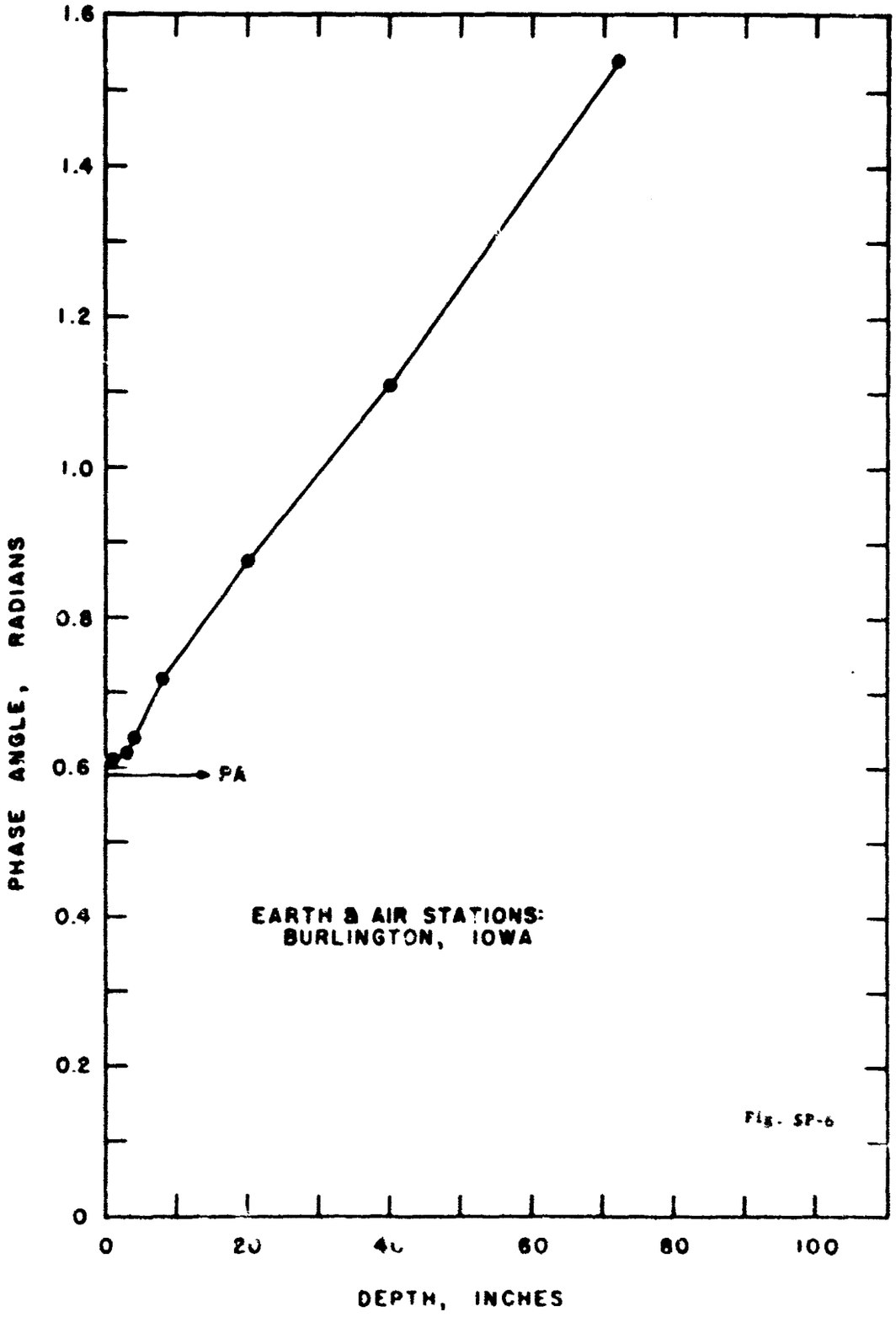

1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
PHASE ANGLE, RADIANS
PA
EARTH & AIR STATIONS:
BURLINGTON, IOWA
0
20
40
60
80
100
DEPTH, INCHES

Fig. SP-6

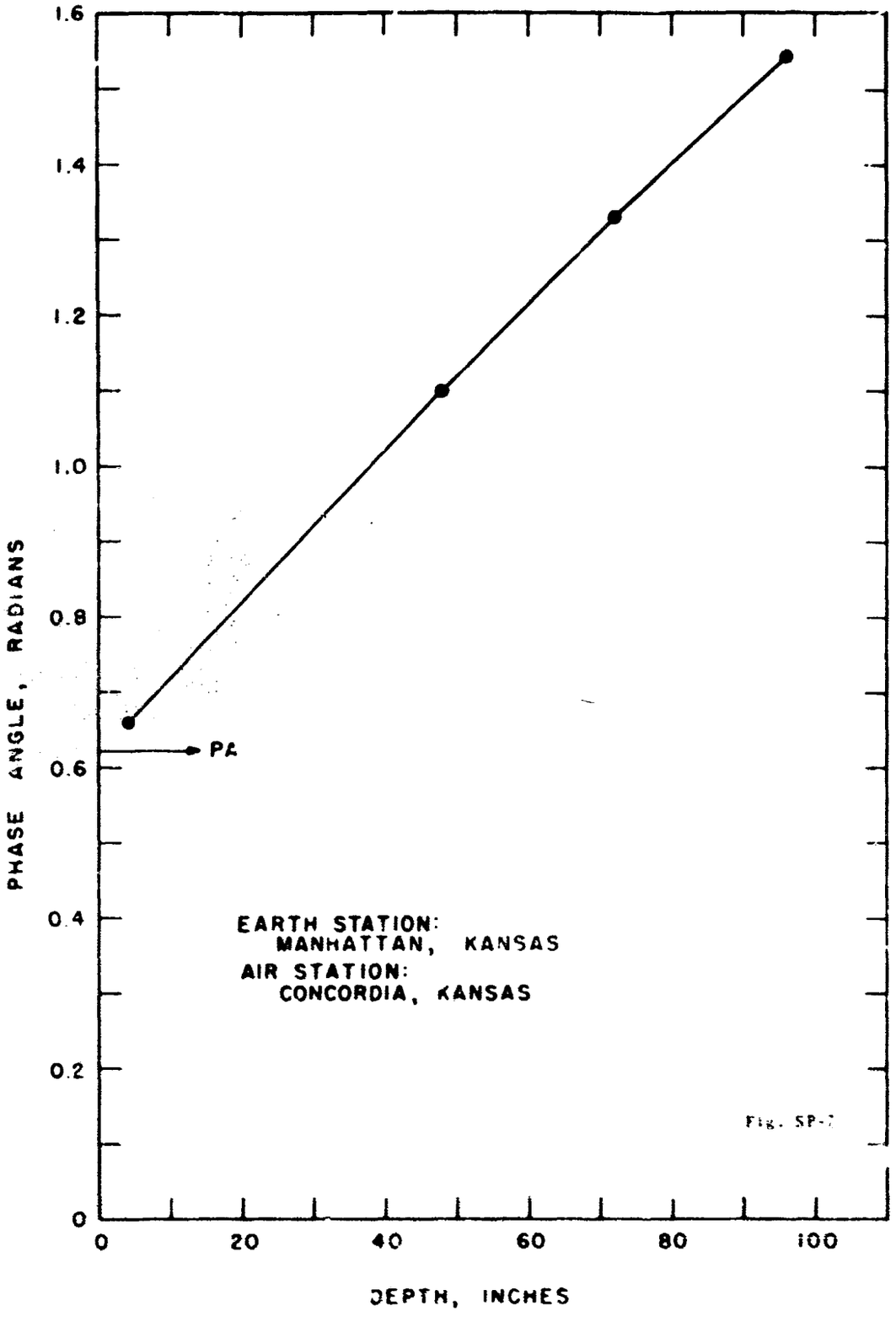

1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
PHASE ANGLE, RADIANS
PA
EARTH STATION:
MANHATTAN, KANSAS
AIR STATION:
CONCORDIA, KANSAS
0
20
40
60
80
100
DEPTH, INCHES

Fig. SP-7

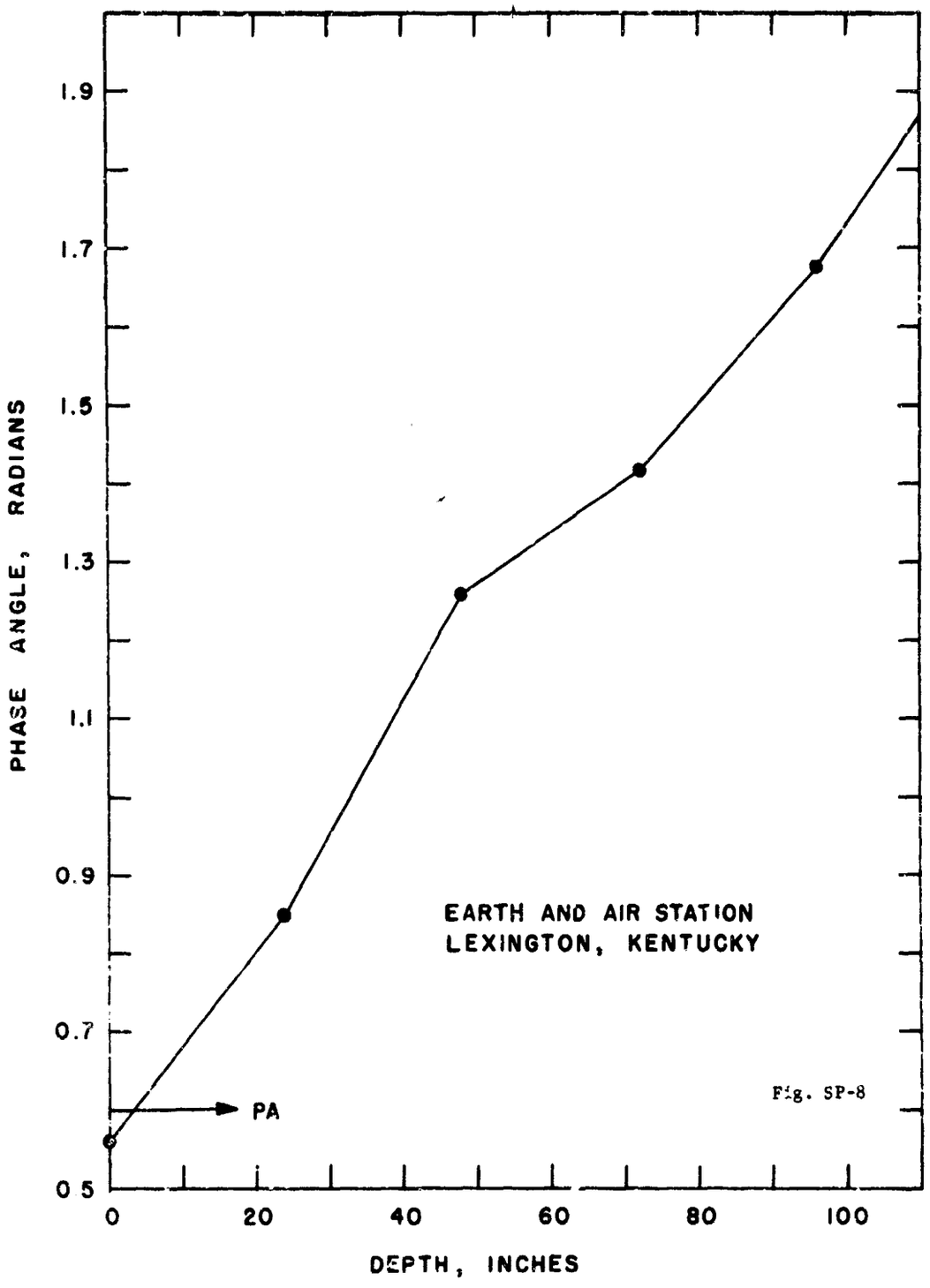

PHASE ANGLE, RADIANS
1.9
1.7
1.5
1.3
1.1
0.9
0.7
0.5
0
20
40
60
80
100
DEPTH, INCHES
PA
EARTH AND AIR STATION
LEXINGTON, KENTUCKY

Fig. SP-8

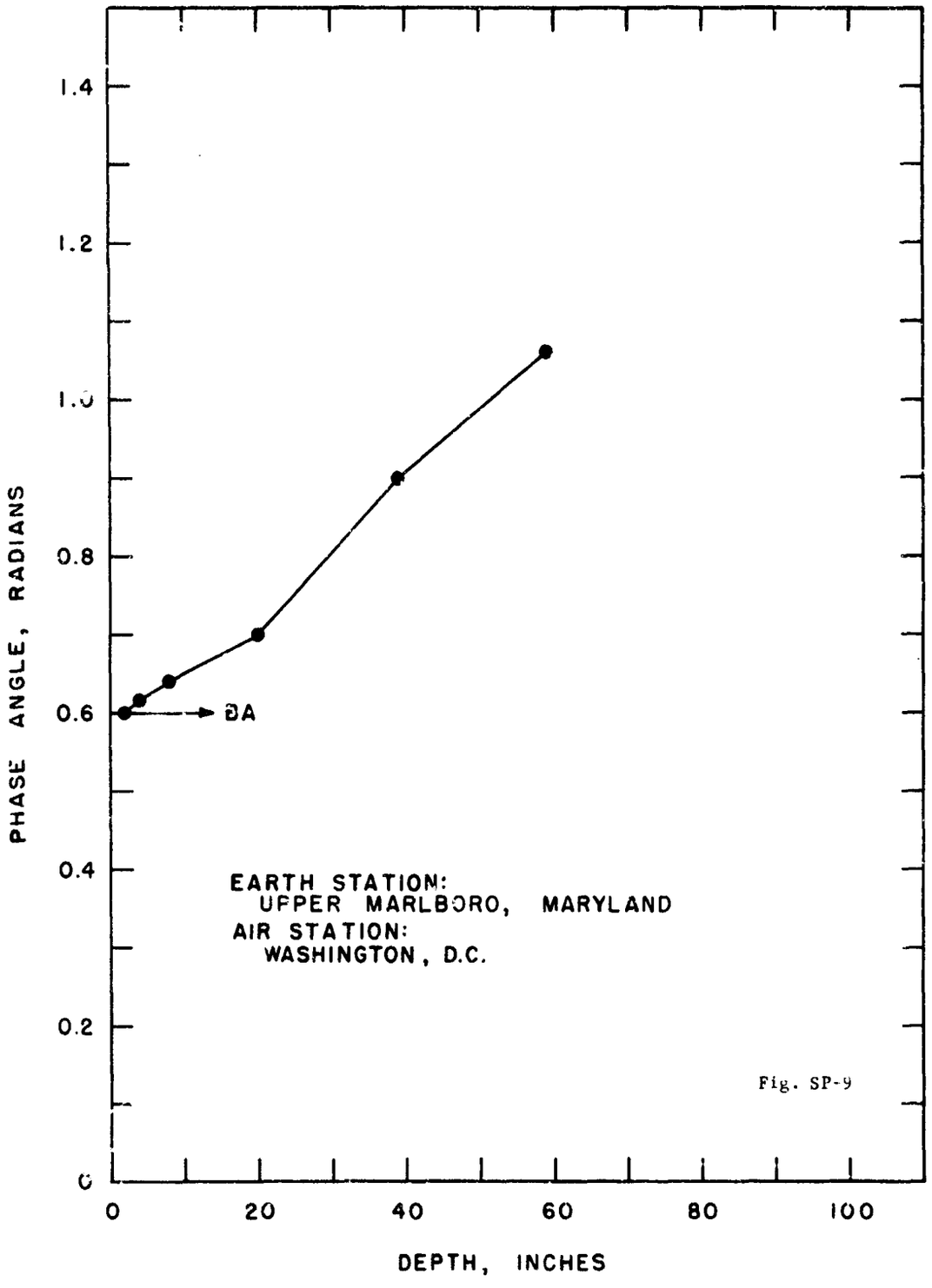

1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
PHASE ANGLE, RADIANS
ΔA
EARTH STATION:
UPPER MARLBORO, MARYLAND
AIR STATION:
WASHINGTON, D.C.
0
20
40
60
80
100
DEPTH, INCHES

Fig. SP-9

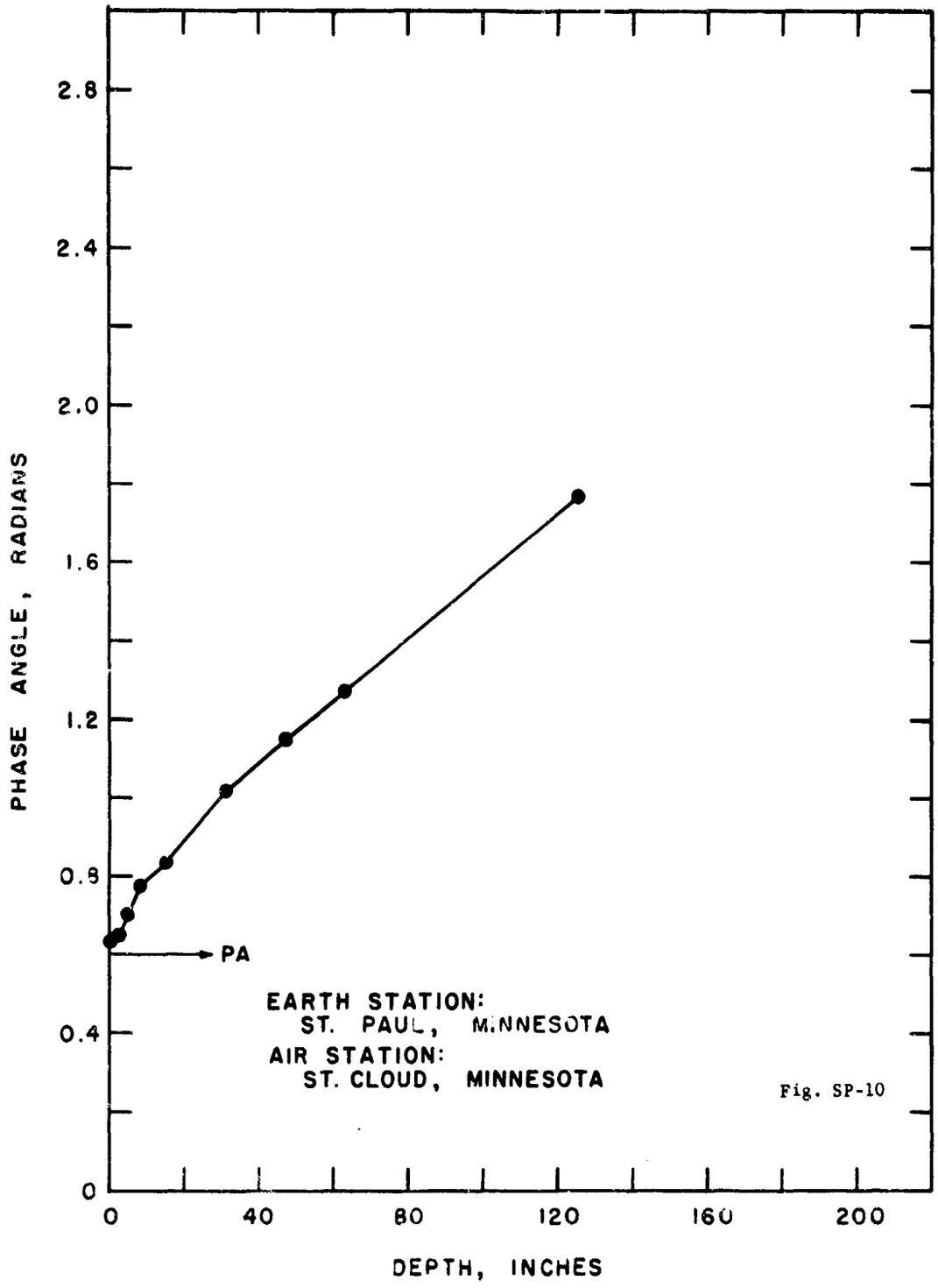

PHASE ANGLE, RADIANS
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0
PA
EARTH STATION:
ST. PAUL, MINNESOTA
AIR STATION:
ST. CLOUD, MINNESOTA
0
40
80
120
160
200
DEPTH, INCHES

Fig. SP-10

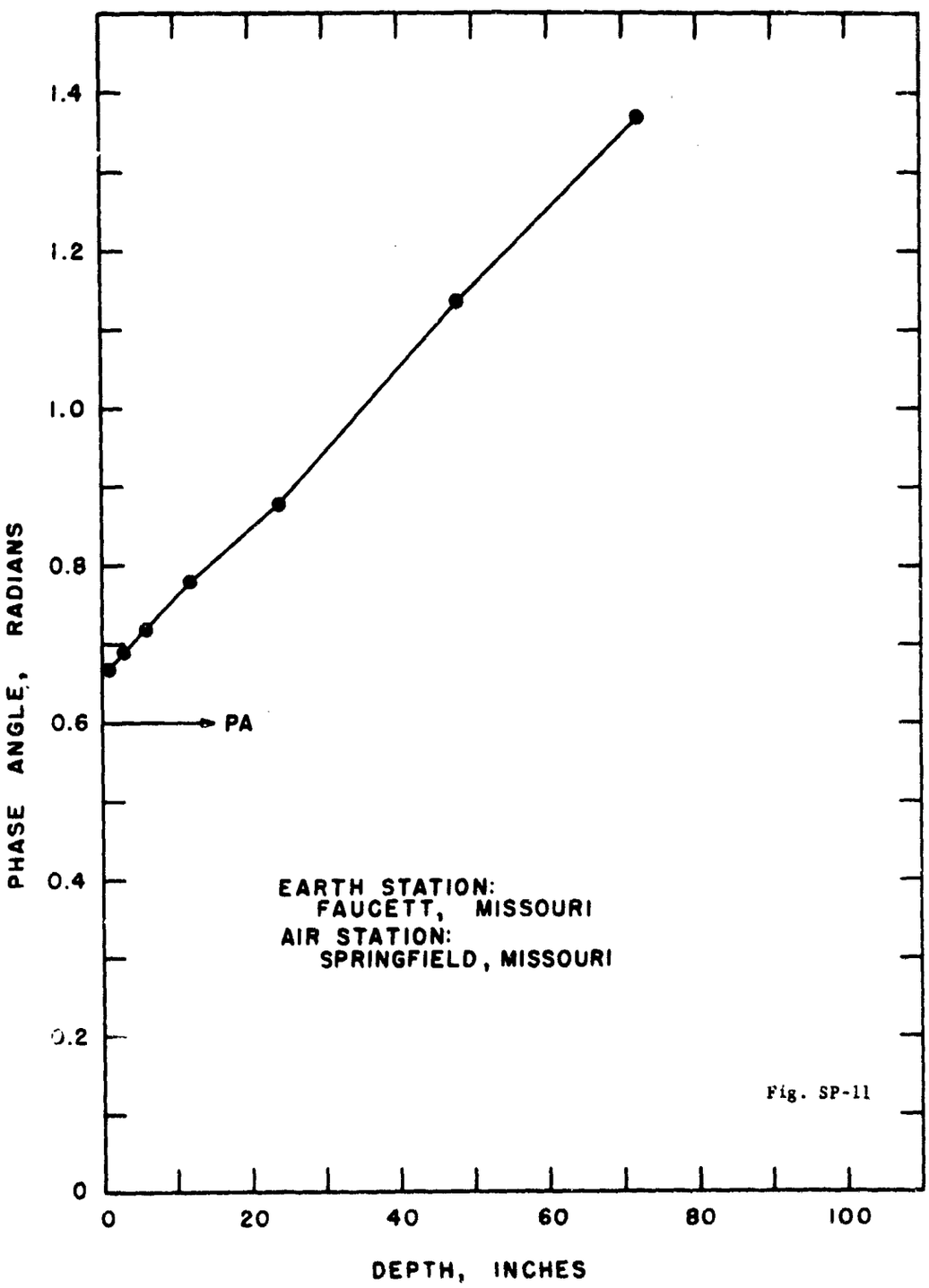

1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
PHASE ANGLE, RADIANS
PA
EARTH STATION:
FAUCETT, MISSOURI
AIR STATION:
SPRINGFIELD, MISSOURI
0
20
40
60
80
100
DEPTH, INCHES

Fig. SP-11

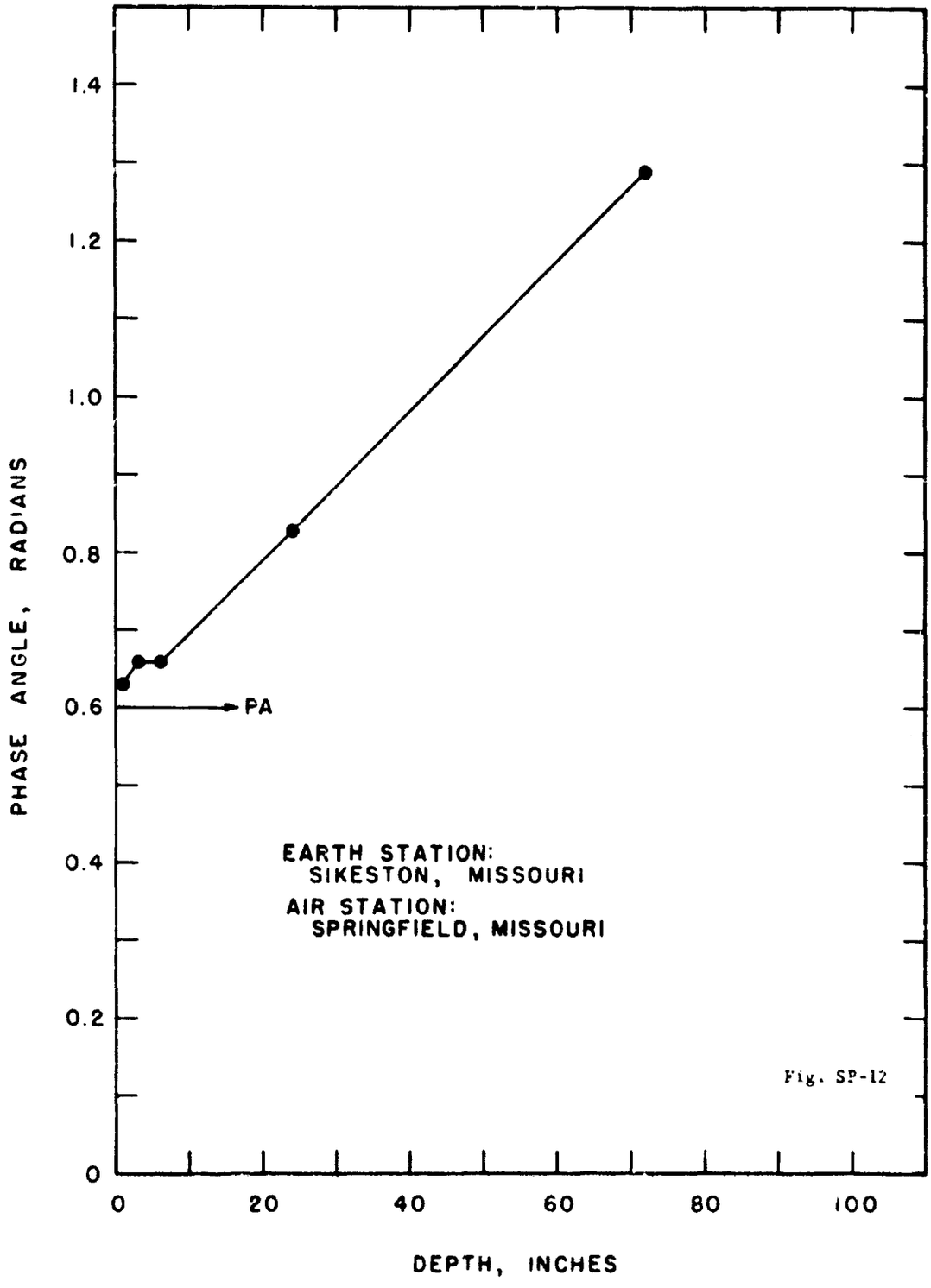

1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
PHASE ANGLE, RADIANS
PA
EARTH STATION:
SIKESTON, MISSOURI
AIR STATION:
SPRINGFIELD, MISSOURI
0
20
40
60
80
100
DEPTH, INCHES

Fig. SP-12

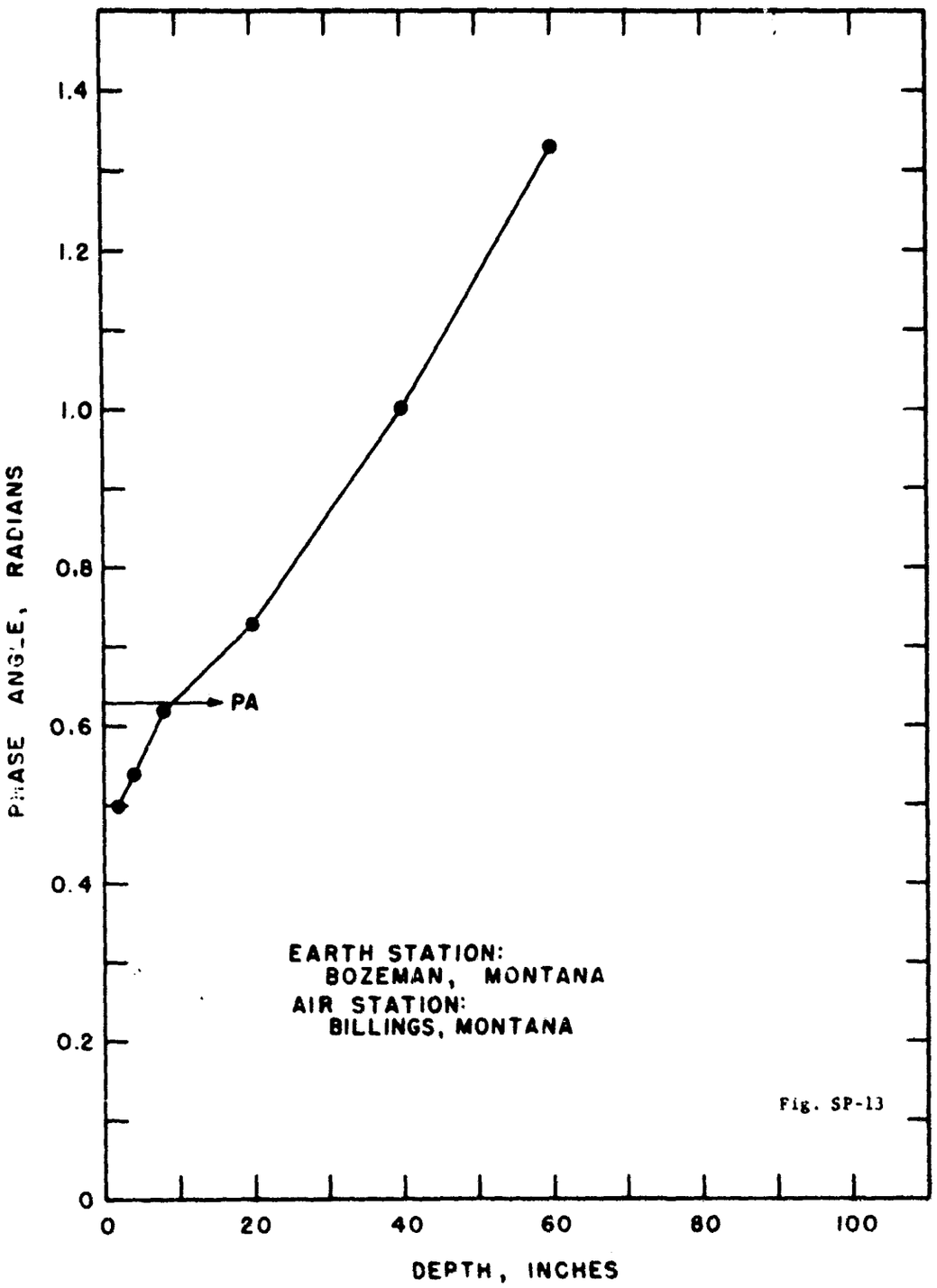

1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
PHASE ANGLE, RADIANS
PA
EARTH STATION:
BOZEMAN, MONTANA
AIR STATION:
BILLINGS, MONTANA
0
20
40
60
80
100
DEPTH, INCHES

Fig. SP-13

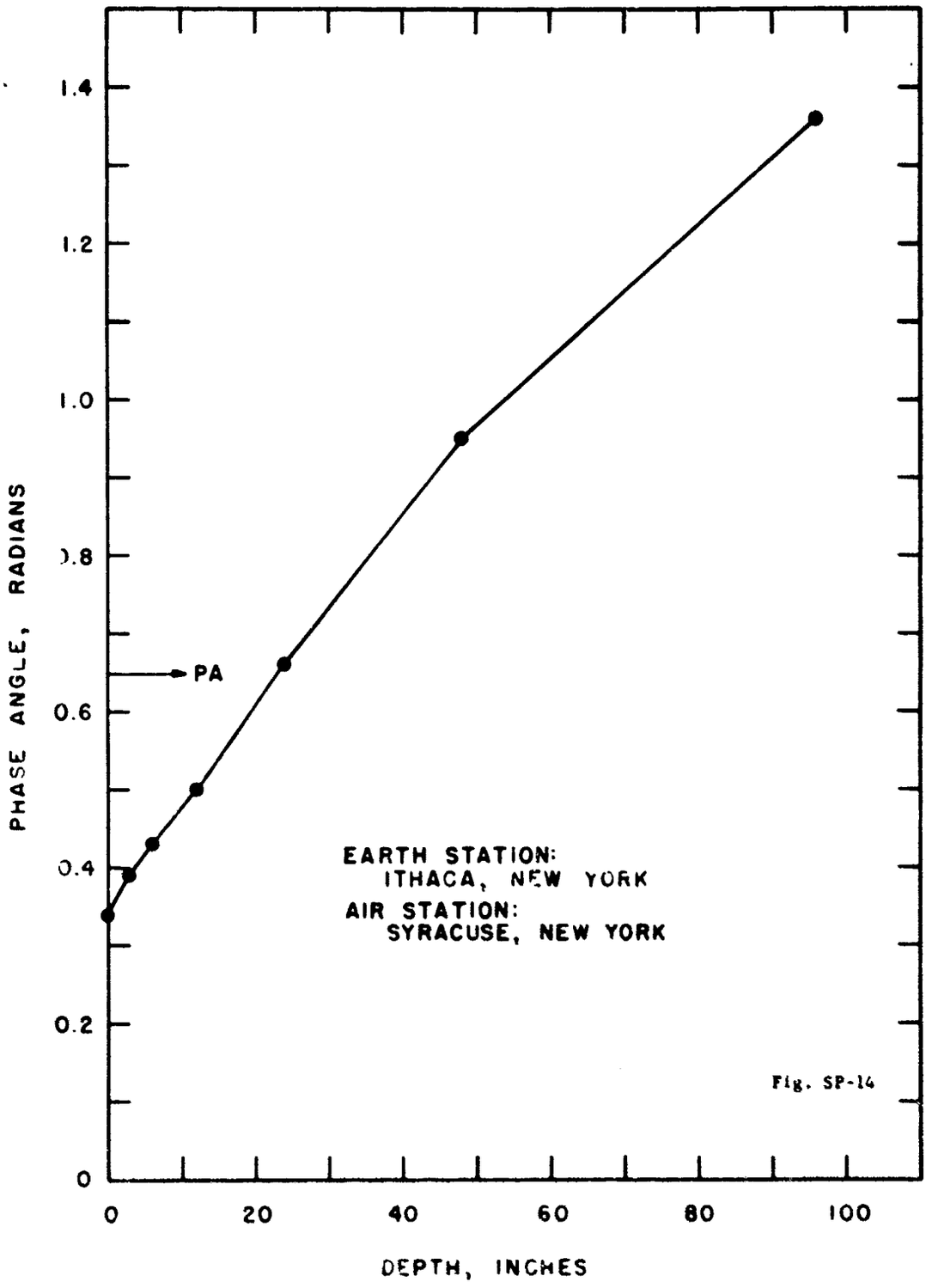

PHASE ANGLE, RADIANS
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
PA
EARTH STATION:
ITHACA, NEW YORK
AIR STATION:
SYRACUSE, NEW YORK
0
20
40
60
80
100
DEPTH, INCHES

Fig. SP-14

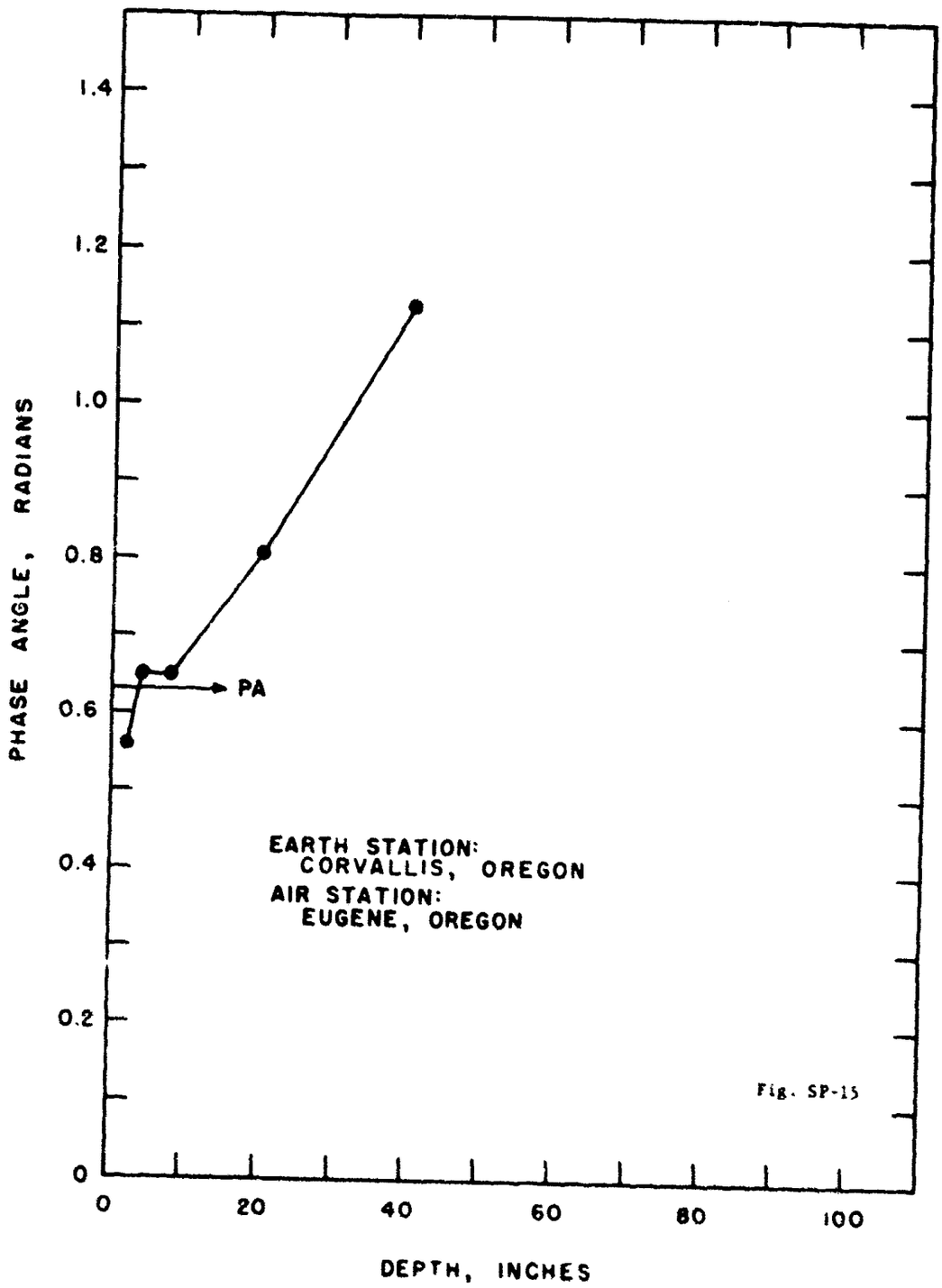

1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
PHASE ANGLE, RADIANS
PA
EARTH STATION:
CORVALLIS, OREGON
AIR STATION:
EUGENE, OREGON
0
20
40
60
80
100
DEPTH, INCHES

Fig. SP-15

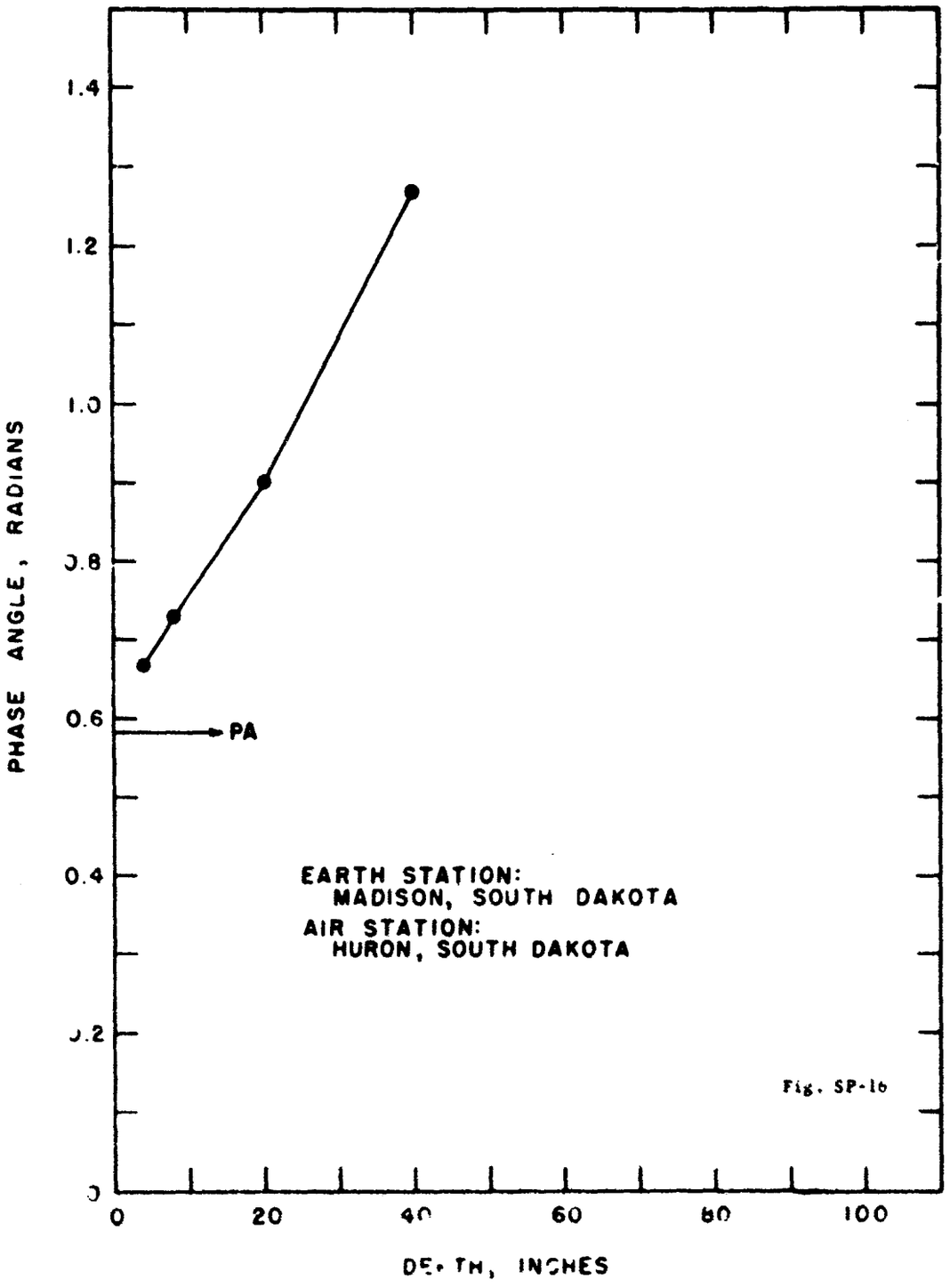

PHASE ANGLE, RADIANS
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
PA
EARTH STATION:
MADISON, SOUTH DAKOTA
AIR STATION:
HURON, SOUTH DAKOTA
0
20
40
60
80
100
DEPTH, INCHES

Fig. SP-16

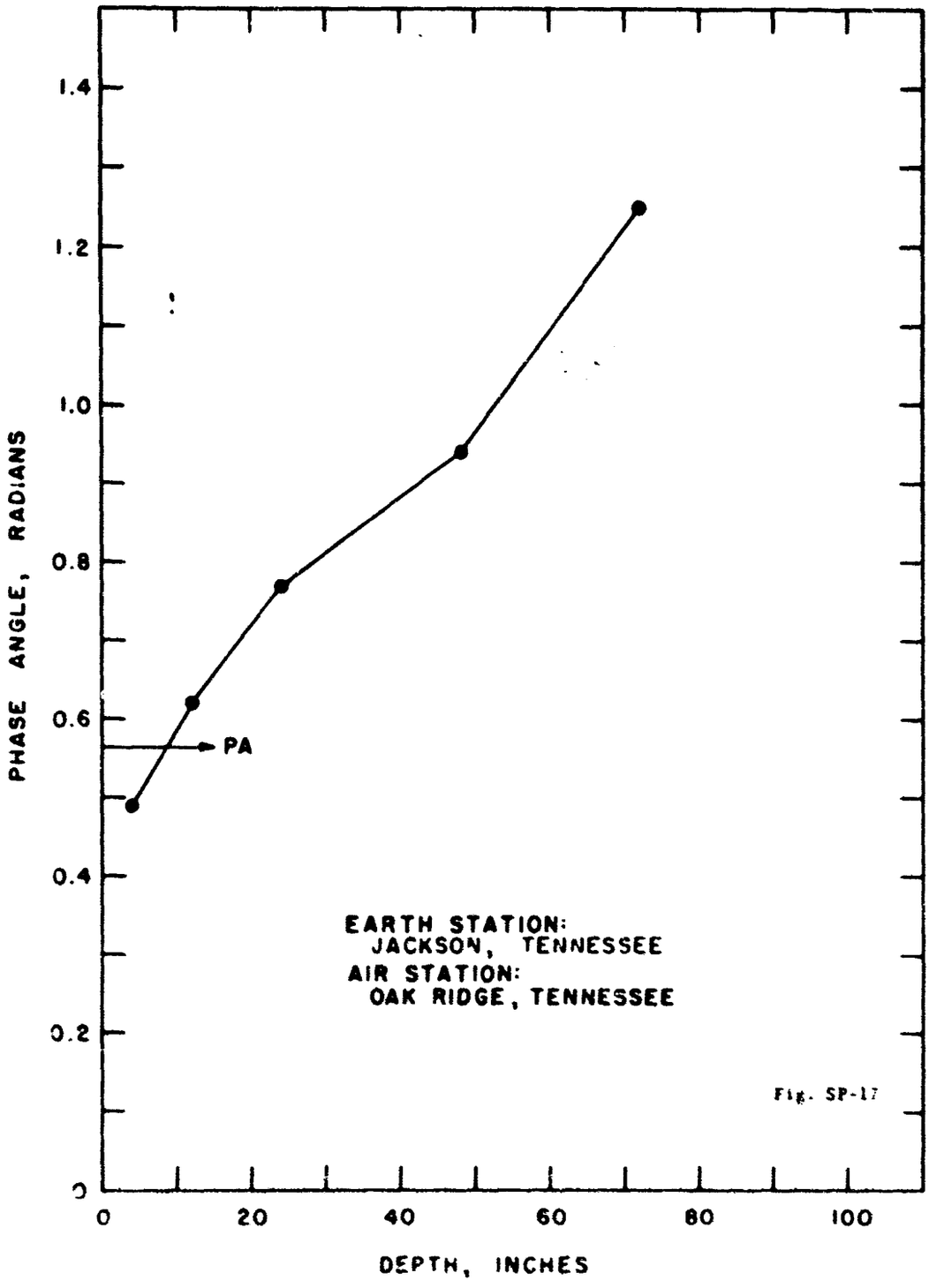

PHASE ANGLE, RADIANS
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
PA
EARTH STATION:
JACKSON, TENNESSEE
AIR STATION:
OAK RIDGE, TENNESSEE
0
20
40
60
80
100
DEPTH, INCHES

Fig. SP-17

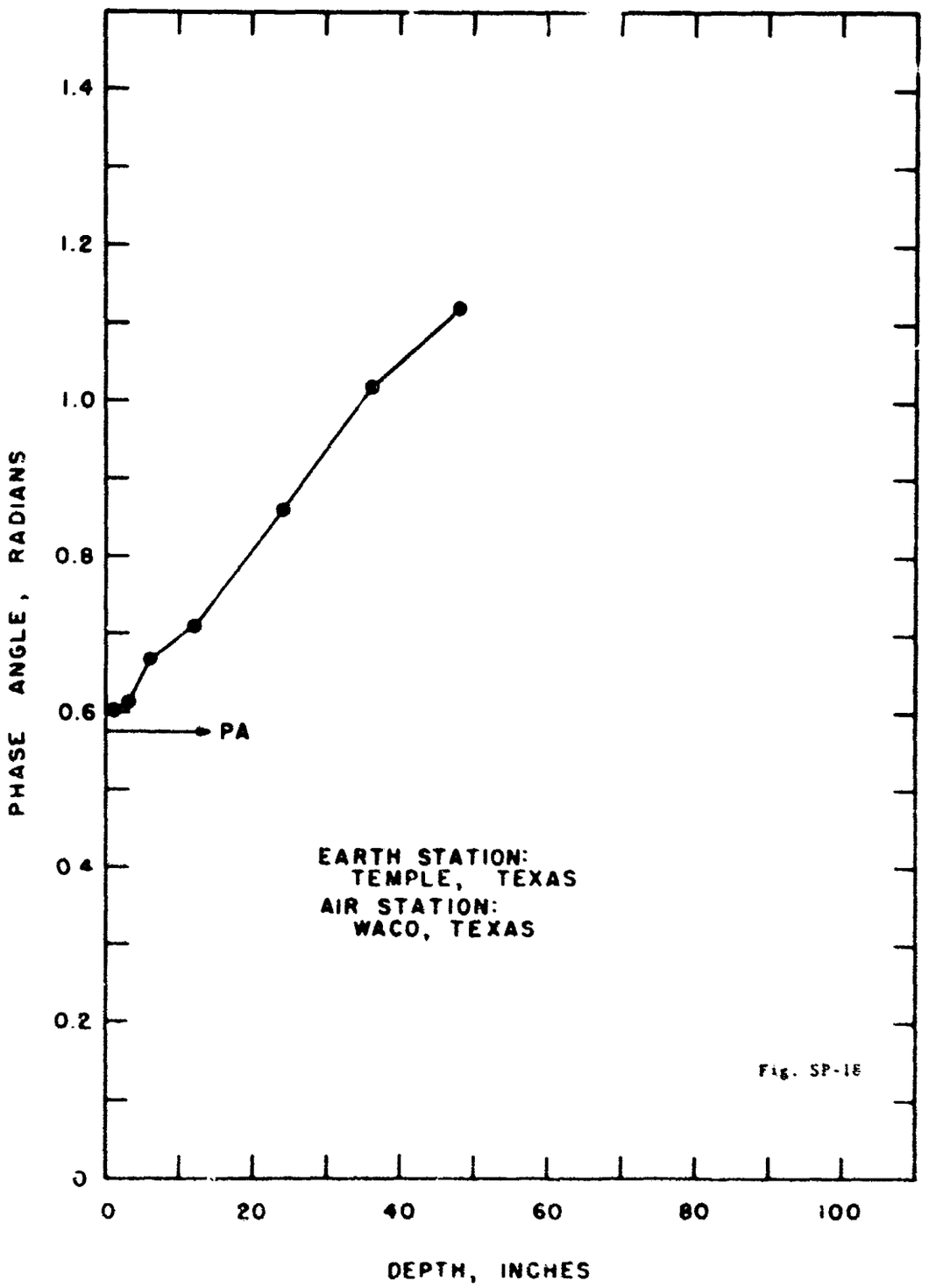
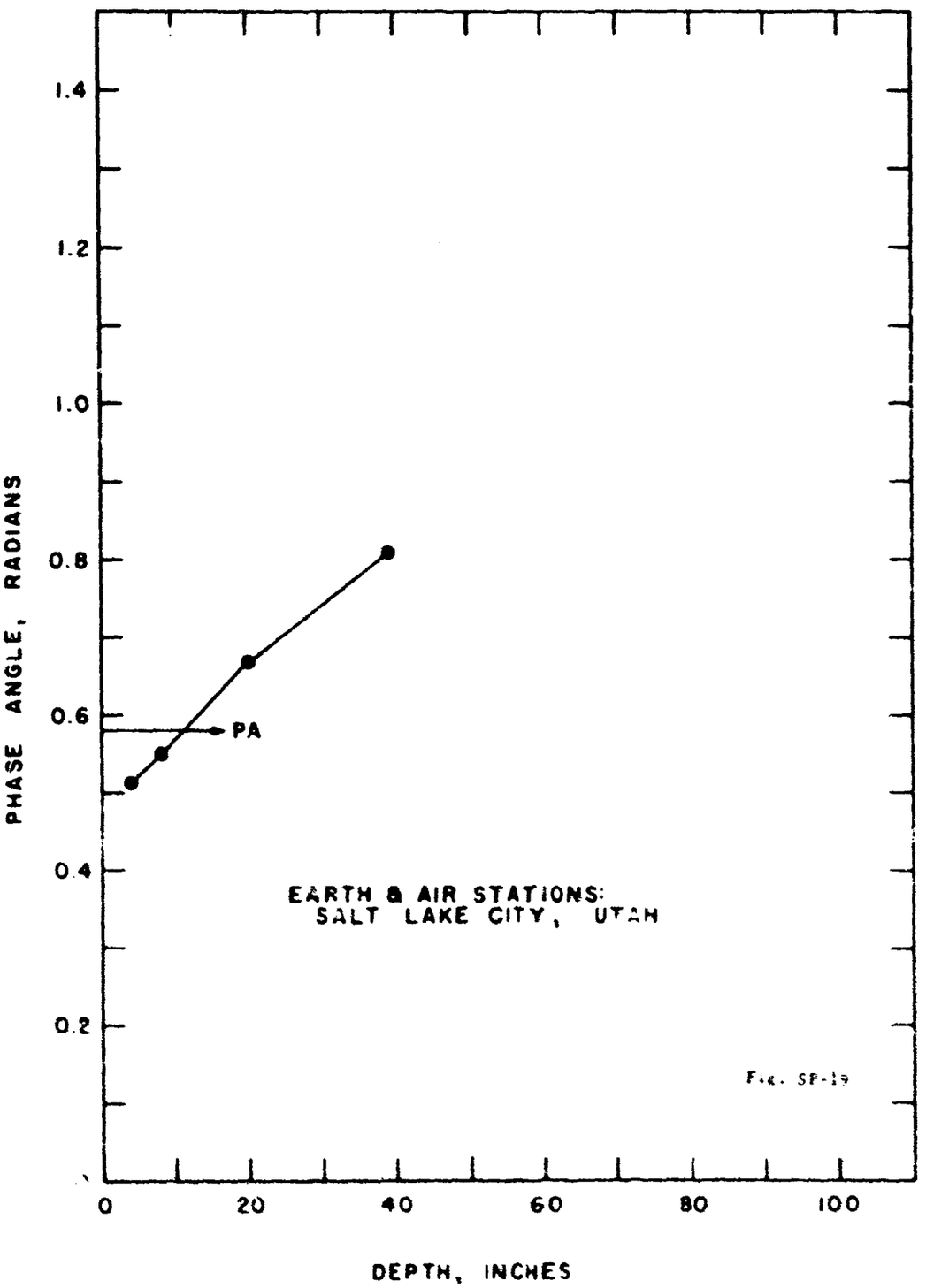

1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
PHASE ANGLE, RADIANS
PA
EARTH STATION:
TEMPLE, TEXAS
AIR STATION:
WACO, TEXAS
0
20
40
60
80
100
DEPTH, INCHES

Fig. SP-18


1.4
1.2
1.0
0.8
0.6
0.4
0.2
PHASE ANGLE, RADIANS
PA
EARTH & AIR STATIONS:
SALT LAKE CITY, UTAH
Fig. SP-19
0
20
40
60
80
100
DEPTH, INCHES

Tables ST-1 to ST-63	Summary of observed earth temperatures, results of least-squares analysis, and calculated earth temperatures using the least-squares constants for all of 63 earth temperature stations
Tables STA-1 to STA-63	Calculated earth temperatures for selected depths and thermal diffusivities, and integrated average temperature for upper 10-ft earth stratum for 63 earth temperature stations

EARTH TEMPERATURE STATION	AUBURN, ALABAMA
TYPE OF SOIL	SANDY SOIL
TYPE OF EARTH SURFACE	UNKNOWN
DATA PROCESSED BY	E.M.FITTON
DATA SOURCE	REFERENCE(4)
PERIOD OF OBSERVATION	1869

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
3.0	48.5	50.5	55.2	65.5	72.2	74.0	86.5	82.2	75.5	64.8	52.2	52.0
6.0	48.2	55.5	53.8	64.8	72.0	73.5	85.8	81.5	75.0	65.2	52.8	51.2
24.0	49.5	50.5	53.8	62.5	70.5	74.2	81.5	80.0	80.8	68.2	58.8	55.0
48.0	52.5	50.5	53.5	59.8	67.2	72.2	77.0	78.0	70.8	70.8	63.5	58.5
96.0	58.0	55.5	55.2	57.2	61.2	67.2	71.0	73.2	75.0	72.5	77.0	63.5

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
3.0	65.0	17.5	0.56	3.0
6.0	65.0	16.6	0.56	3.4
24.0	65.5	16.1	0.77	2.0
48.0	64.6	12.8	0.91	1.7
96.0	65.6	10.5	1.53	2.6

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
3.0	48.4	50.7	56.5	65.0	73.2	79.4	81.6	79.4	73.1	64.9	56.4	50.5
6.0	48.7	50.8	56.4	64.6	72.7	78.9	81.3	79.2	73.2	65.2	56.9	51.0
24.0	50.9	51.8	56.0	62.8	70.1	76.1	79.1	78.3	73.8	67.1	59.6	53.8
48.0	53.6	53.3	55.9	61.1	67.2	72.9	76.3	76.7	73.9	68.8	62.5	57.0
96.0	58.3	56.7	57.1	59.7	63.6	68.1	71.5	73.3	72.8	70.2	66.2	61.9

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =65.0,B0=17.0,PC=0.49 ,D=.047

EARTH TEMPERATURE STATION AUBURN, ALABAMA

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 65.0 ,BO= 17.0 AND PO= 0.49

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	51.9	52.3	55.9	62.1	68.9	74.9	78.1	77.7	73.9	67.8	60.7	55.0
48.0	55.5	54.5	56.2	60.4	65.6	70.9	74.4	75.5	73.7	69.6	64.1	59.0
72.0	58.5	56.8	57.2	59.7	63.5	67.9	71.3	73.2	72.7	70.3	66.3	62.1
96.0	61.0	59.0	58.5	59.7	62.3	65.7	68.8	71.0	71.5	70.2	67.5	64.2
120.0	62.9	60.9	59.9	60.3	61.9	64.4	67.0	69.1	70.1	69.7	68.0	65.6
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	56.5	55.7	57.2	60.9	65.6	70.2	73.4	74.3	72.7	69.1	64.2	59.7

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	76.5	77.5	77.7	77.9	78.2
48.0	72.8	74.9	75.5	75.9	76.5
72.0	69.6	72.4	73.2	73.8	74.6
96.0	67.1	70.1	71.0	71.7	72.8
120.0	65.6	68.1	69.1	69.9	71.1
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	71.7	73.7	74.3	74.8	75.5

EARTH TEMPERATURE STATION	DECATUR, ALABAMA
TYPE OF SOIL	SILT LOAM
TYPE OF EARTH SURFACE	GRASS
DATA PROCESSED BY	
DATA SOURCE	US WEATHER R.C.
PERIOD OF OBSERVATION	1949-1951

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
4.0	39.6	45.3	47.2	55.2	67.0	72.4	75.0	71.9	67.5	61.5	41.1	35.4
12.0	43.7	45.2	46.7	54.6	67.	76.3	77.1	75.9	70.8	64.9	51.6	44.5
24.0	42.8	43.8	46.9	51.3	60.1	68.5	70.3	73.3	68.2	62.3	53.6	45.4
48.0	49.2	46.8	49.8	52.5	59.2	67.2	71.3	76.8	72.9	68.6	59.8	51.4
72.0	51.4	50.9	51.1	52.8	58.1	62.9	67.1	72.3	69.0	69.4	65.9	59.4

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
4.0	56.9	18.7	C.47	3.9
12.0	60.1	18.0	0.67	3.6
24.0	57.3	15.1	0.82	3.0
48.0	60.6	14.1	1.06	3.6
72.0	61.0	10.8	1.37	3.0

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
4.0	39.8	42.7	49.6	59.4	68.8	75.8	78.2	75.4	68.0	58.4	48.8	42.1
12.0	41.3	43.3	49.1	57.9	66.8	73.8	76.6	74.8	68.5	59.9	50.8	44.2
24.0	43.6	44.4	48.7	56.1	64.1	70.9	74.3	73.7	69.0	61.8	53.6	47.0
48.0	47.8	46.9	49.0	53.9	60.0	66.0	70.0	71.1	68.8	64.0	57.7	51.9
72.0	51.5	49.6	50.1	53.0	57.4	62.4	66.3	68.4	67.8	64.9	60.3	55.5

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =59.0, B0=20.0, P0=0.45 , D=.023

EARTH TEMPERATURE STATION DECATUR, ALABAMA

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 59.0 ,BO= 21.0 AND PO= 0.45

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	42.7	43.5	48.2	56.1	64.5	71.7	75.3	74.5	69.5	61.8	53.1	46.2
48.0	47.0	46.1	48.4	53.7	60.3	66.7	70.9	71.9	69.4	64.2	57.4	51.2
72.0	50.8	48.8	49.5	52.8	57.6	62.9	67.1	69.2	68.4	65.2	60.2	55.0
96.0	53.8	51.5	51.0	52.7	56.0	60.2	64.0	66.5	66.9	65.2	61.8	57.7
120.0	56.2	53.8	52.7	53.3	55.3	58.5	61.6	64.2	65.3	64.7	62.5	59.5
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	48.3	47.5	49.6	54.3	60.1	65.8	69.6	70.5	68.2	63.6	57.6	52.1

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	73.1	74.2	74.5	74.7	75.0
48.0	68.7	71.3	71.9	72.4	73.1
72.0	64.8	68.2	69.2	69.9	70.9
96.0	61.8	65.4	66.3	67.4	68.7
120.0	59.8	63.0	64.2	65.2	66.6
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	67.3	69.8	70.5	71.1	71.9

EARTH TEMPERATURE STATION — TEMPE, ARIZONA
TYPE OF SOIL — SANDY SOIL
TYPE OF EARTH SURFACE — CITRUS GROVE
DATA PROCESSED BY
DATA SOURCE — US WEATHER R.C.

PERIOD OF OBSERVATION — 1957-1959

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
8.0	49.7	53.3	60.6	68.9	73.8	81.9	86.4	86.8	78.7	68.9	55.5	50.1
20.0	54.0	56.1	62.5	69.0	74.3	81.5	86.4	87.1	82.6	73.4	62.0	55.9
39.0	56.7	56.6	60.4	65.0	70.4	77.4	82.6	83.5	81.5	75.0	66.3	60.0
89.0	63.2	61.3	61.1	62.8	68.3	70.9	75.3	77.6	78.2	75.7	71.7	67.3

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
8.0	68.0	18.6	C.53	2.5
20.C	70.5	16.4	0.66	1.9
39.0	69.7	13.7	C.88	1.1
89.0	69.5	8.6	1.32	1.3

CALCULATEC EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
8.0	51	53.8	60.0	69.3	78.6	85.7	88.5	86.3	79.6	70.5	61.0	54.2
20.0	53.7	54.7	59.6	67.5	75.9	82.9	86.3	85.3	80.1	72.3	63.7	57.0
39.0	57.0	56.6	59.5	65.5	72.5	79.0	82.9	83.5	80.2	74.4	67.2	60.9
89.0	64.1	61.9	61.7	63.8	67.5	71.9	75.7	78.1	78.2	76.1	72.3	68.0

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =70.0,BO=20.0,PO=0.47 ,D=.027

EARTH TEMPERATURE STATION TEMPE,ARIZONA

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 70.0 ,BO= 20.0 AND PO= 0.47

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	54.5	55.2	59.5	66.9	74.9	81.9	85.4	84.9	80.2	73.0	64.7	58.1
48.0	58.7	57.7	59.8	64.8	71.0	77.1	81.2	82.3	80.0	75.1	68.7	62.8
72.0	62.3	60.3	60.9	63.9	68.4	73.6	77.6	79.6	79.0	76.0	71.3	66.4
96.0	65.2	62.9	62.4	63.9	67.0	71.0	74.6	77.1	77.6	76.0	72.8	68.9
120.0	67.4	65.1	64.0	64.5	66.4	69.4	72.4	74.9	76.0	75.5	73.5	70.6
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	59.9	59.0	60.9	65.3	70.9	76.3	80.0	81.0	78.9	74.6	68.8	63.6

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	83.4	84.6	84.9	85.1	85.4
48.0	79.2	81.7	82.3	82.8	83.4
72.0	75.4	78.7	79.6	80.3	81.3
96.0	72.6	76.0	77.1	78.0	79.2
120.0	70.7	73.8	74.9	75.8	77.2
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	77.9	80.3	81.0	81.5	82.3

EARTH TEMPERATURE STATION	TUCSON, ARIZONA
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	BARE
DATA PROCESSED BY	JEN-HU-CHANG
DATA SOURCE	REFERENCE(5) 1958
PERIOD OF OBSERVATION	1937-1938

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
3.0	53.6	53.9	61.2	75.6	83.2	85.3	80.3	81.1	79.8	77.0	65.5	53.5
12.0	57.6	56.8	61.4	70.5	77.2	83.4	88.6	90.6	88.8	81.6	71.2	61.1
24.0	62.8	61.8	65.3	70.2	76.2	81.4	86.0	88.1	87.4	81.8	74.3	65.8
72.0	64.7	62.5	63.4	65.5	70.9	75.6	79.1	82.2	83.0	81.0	75.4	68.8

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
3.0	70.9	16.0	0.52	4.4
12.0	74.2	17.1	0.87	1.5
24.0	75.2	13.2	0.96	1.1
72.0	72.7	10.3	1.28	0.8

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
3.0	58.0	58.0	62.2	70.1	79.1	87.2	91.9	92.0	87.5	79.7	70.5	62.7
12.0	59.6	58.9	62.3	69.3	77.6	85.5	90.3	91.1	87.4	80.5	71.9	64.4
24.0	61.5	60.2	62.6	68.5	76.0	83.4	88.3	89.8	87.1	81.4	73.6	66.5
72.0	68.1	65.4	65.1	67.5	71.8	77.1	81.7	84.6	84.8	82.4	77.9	72.8

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =75.0,B0=18.0,P0=0.77 ,D=.039

EARTH TEMPERATURE STATION TUCSON,ARIZONA

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 75.0 ,BO= 18.0 AND PO= 0.77

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
	MONTH OF YEAR											
24.0	62.4	60.8	62.8	68.2	75.3	82.4	87.4	89.2	87.0	81.7	74.4	67.5
48.0	66.6	64.1	64.4	67.5	72.6	78.4	83.2	85.9	85.6	82.4	77.2	71.5
72.0	69.9	67.1	66.2	67.7	71.1	75.6	79.9	82.9	83.7	82.2	78.7	74.3
96.0	72.5	69.6	68.2	68.5	70.6	73.9	77.4	80.3	81.8	81.5	79.3	76.1
120.0	74.3	71.7	70.0	69.6	70.6	72.9	75.6	78.3	80.0	80.4	79.3	77.1
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	67.5	65.3	65.5	66.3	72.8	78.1	82.3	84.7	84.4	81.6	76.9	71.9

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	87.3	88.8	89.2	89.4	89.8
48.0	82.5	85.2	85.9	86.5	87.3
72.0	78.7	81.9	82.9	83.7	84.8
96.0	76.3	79.3	80.3	81.2	82.5
120.0	74.9	77.3	78.3	79.1	80.4
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	81.6	84.0	84.7	85.3	86.1

EARTH TEMPERATURE STATION — BRAWLEY,CALIFORNIA
TYPE OF SOIL — SILTY CLAY
TYPE OF EARTH SURFACE — BARE
DATA PROCESSED BY
DATA SOURCE — CLIMATOLOGICAL DATA

PERIOD OF OBSERVATION — 1960-1962

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
4.0	49.5	55.7	62.8	74.4	78.9	88.2	93.6	94.2	88.3	76.1	63.0	52.8
8.0	55.8	60.5	65.9	76.0	80.6	89.2	95.6	95.4	91.1	81.8	69.2	60.0
12.0	59.2	62.9	67.7	77.0	81.3	89.8	96.0	97.1	93.0	83.6	72.6	63.6
20.0	61.5	64.1	67.9	76.1	80.6	87.7	93.6	95.6	92.6	85.0	75.4	66.7
39.0	65.5	65.9	67.6	73.2	77.5	82.5	88.3	91.2	90.5	85.8	79.1	71.5
79.0	72.8	70.9	70.9	72.8	75.7	78.7	82.7	86.0	87.2	86.1	82.6	77.8

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
4.0	73.2	21.5	C.61	3.0
8.0	76.9	19.4	0.70	2.6
12.0	78.8	18.2	C.75	2.3
20.0	79.0	16.3	C.84	1.9
39.0	78.2	12.8	1.08	1.5
79.0	78.7	8.3	1.48	0.8

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
4.0	60.0	61.4	67.2	76.5	86.1	94.2	97.9	96.6	90.4	81.4	71.4	63.7
8.0	61.0	61.9	67.1	75.7	85.0	93.0	96.9	96.1	90.6	82.1	72.5	64.9
12.0	61.9	62.4	67.0	75.1	84.0	91.8	96.0	95.6	90.7	82.7	73.6	66.1
20.0	63.8	63.5	67.0	74.0	82.2	89.6	94.1	94.6	90.7	83.8	75.4	68.2
39.0	67.8	66.2	67.8	72.5	78.8	85.3	90.0	91.8	90.1	85.4	78.9	72.8
79.0	74.4	71.7	70.9	72.2	75.3	79.5	83.4	86.2	87.1	85.7	82.5	78.5

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =79.0,BO=20.0,PO=0.60 ,D=.019

EARTH TEMPERATURE STATION BRAWLEY,CALIFORNIA

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 79.0 ,BO= 20.C AND PO= 0.60

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	64.0	63.6	67.1	73.9	82.0	89.4	93.9	94.4	90.7	83.9	75.6	68.5
48.0	68.4	66.6	68.0	72.3	78.4	84.8	89.4	91.4	89.9	85.6	79.3	73.2
72.0	72.1	69.6	69.5	72.0	76.2	81.4	85.7	88.4	88.4	86.0	81.5	76.6
96.0	75.0	72.3	71.3	72.4	75.1	79.0	82.8	85.7	86.7	85.6	82.7	78.9
120.0	77.2	74.6	73.1	73.2	74.8	77.6	80.7	83.4	84.9	84.8	83.1	80.4
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	69.6	68.0	69.2	73.1	78.4	84.1	88.3	90.0	88.7	84.8	79.3	73.8

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	92.7	94.1	94.4	94.7	95.0
48.0	87.9	90.7	91.4	91.9	92.7
72.0	83.9	87.4	88.4	89.1	90.2
96.0	81.1	84.5	85.7	86.6	87.9
120.0	79.4	82.3	83.4	84.3	85.8
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	86.7	89.3	90.0	90.6	91.5

EARTH TEMPERATURE STATION	DAVIS,CALIFORNIA
TYPE OF SOIL	RECENT ALLUVIUM
TYPE OF EARTH SURFACE	UNCROPPED
DATA PROCESSED BY	E.P.FITTON
DATA SOURCE	REFERENCE(4)
PERIOD OF OBSERVATION	1925-1927

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
0.5	48.0	51.1	58.4	63.2	74.8	82.0	90.6	86.0	77.4			
3.0	48.2	49.9	55.2	61.9	72.9	78.9	86.6	83.2	76.4			
6.0	48.8	50.2	54.5	60.9	72.0	78.0	87.2	84.5	79.4			
12.0	48.5	50.2	53.7	60.2	70.8	76.4	84.4	83.0	77.2			
24.0	53.2	51.9	54.6	59.7	68.4	72.9	82.8	82.8	78.2			
36.0	51.2	51.4	54.3	60.1	68.8	72.9	80.8	82.5	78.6			

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
0.5	67.9	19.4	0.63	2.2
3.0	66.2	19.2	0.67	1.4
6.0	67.0	18.3	0.79	1.5
12.0	65.9	17.4	0.78	1.3
24.0	66.9	15.2	0.97	1.5
36.0	66.3	15.4	0.93	1.3

EARTH TEMPERATURE STATION DAVIS,CALIFORNIA

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 66.0 ,BO= 19.0 AND PO= 0.63

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	51.9	51.3	54.4	60.8	68.4	75.5	80.0	80.7	77.4	71.1	63.3	56.4
48.0	56.1	54.3	55.4	59.4	65.1	71.2	75.7	77.7	76.5	72.5	66.6	60.8
72.0	59.6	57.1	56.9	59.1	63.1	68.0	72.2	74.8	75.0	72.8	68.7	64.0
96.0	62.4	59.7	58.7	59.6	62.1	65.8	69.4	72.2	73.3	72.4	69.7	66.1
120.0	64.4	61.9	60.5	60.4	61.9	64.5	67.4	70.1	71.6	71.5	70.0	67.5
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	57.2	55.5	56.5	60.1	65.2	70.6	74.6	76.4	75.4	71.8	66.6	61.3

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	79.0	80.4	80.7	81.0	81.3
48.0	74.4	77.0	77.7	78.3	79.0
72.0	70.6	73.9	74.8	75.6	76.6
96.0	67.9	71.1	72.2	73.1	74.4
120.0	66.3	69.0	70.1	70.9	72.3
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	73.3	75.7	76.4	77.0	77.8

EARTH TEMPERATURE STATION	FT. COLLINS,COLO.
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	UNKNOWN
DATA PROCESSED BY	E.M.FITTON
DATA SOURCE	REFERENCE(4)
PERIOD OF OBSERVATION	1869-1927

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
3.0	27.7	29.6	36.5	46.0	56.5	66.7	71.4	69.3	61.1	48.3	36.7	29.7
6.0	29.3	30.6	37.1	47.4	56.6	67.0	71.9	70.4	62.8	50.8	39.0	30.2
12.0	32.8	31.1	36.6	45.5	55.8	65.5	70.9	70.1	63.7	52.3	40.7	33.2
24.0	32.9	32.7	36.8	45.3	53.3	62.5	68.5	68.8	64.0	54.4	43.7	36.5
36.0	35.4	32.6	37.1	43.6	51.1	59.1	65.2	66.6	63.4	55.5	46.0	38.9
72.0	42.5	40.5	40.8	44.2	48.8	54.2	59.2	61.8	62.0	58.0	52.1	46.5

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
3.0	48.4	22.1	0.58	1.2
6.0	49.5	21.9	0.61	1.2
12.0	50.0	20.4	0.69	1.5
24.0	50.0	18.6	0.78	0.9
36.0	49.6	16.6	0.90	0.8
72.0	50.9	10.9	1.21	0.5

EARTH TEMPERATURE STATION FT. COLLINS,COLO.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 50.0 ,BO= 24.0 AND PO= 0.54

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	31.7	31.8	36.4	45.0	54.7	63.3	68.2	68.2	63.2	54.8	44.9	36.6
48.0	36.9	35.1	37.2	42.8	50.1	57.7	63.0	64.9	62.6	57.1	49.5	42.2
72.0	41.2	38.6	38.8	42.1	47.3	53.5	58.6	61.4	61.1	57.9	52.4	46.4
96.0	44.8	41.7	40.8	42.3	45.8	50.6	55.0	58.3	59.2	57.6	54.0	49.3
120.0	47.4	44.4	42.9	43.2	45.3	48.7	52.4	55.6	57.1	56.8	54.6	51.2
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	38.3	36.8	38.6	43.6	50.1	56.8	61.5	63.2	61.2	56.3	49.5	43.1

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	66.3	67.9	68.2	68.5	68.9
48.0	60.9	64.0	64.9	65.5	66.3
72.0	56.2	60.3	61.4	62.3	63.6
96.0	52.8	56.9	58.3	59.3	60.9
120.0	50.6	54.2	55.6	56.7	58.4
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	59.4	62.3	63.2	63.9	64.9

EARTH TEMPERATURE STATION	FT. COLLINS,COLO.
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	GRASS
DATA PROCESSED BY	JEN-HU-CHANG
DATA SOURCE	REFERENCE(5) 1958
PERIOD OF OBSERVATION	1906-1946

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
3.0	28.1	30.2	37.1	47.1	56.8	67.2	72.6	70.3	61.7	49.0	37.2	30.2
6.0	29.4	31.0	37.4	47.8	57.0	67.3	72.3	71.1	63.3	51.2	39.1	31.7
12.0	30.7	31.6	37.2	47.3	56.4	66.1	72.1	71.2	64.4	53.1	41.2	33.8
24.0	33.3	33.2	37.3	45.8	54.2	63.2	69.6	69.8	64.7	55.1	44.4	37.0
36.0	36.1	35.4	37.8	44.5	52.1	60.1	66.6	68.0	64.6	56.6	47.2	40.0
72.0	43.1	41.2	41.5	44.9	49.9	55.8	61.1	63.9	63.5	59.3	53.3	47.4

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
3.0	49.1	22.2	C.58	1.3
6.0	50.0	21.8	0.61	1.1
12.0	50.5	21.1	0.67	1.0
24.0	50.7	18.9	C.78	0.9
36.0	50.8	16.5	0.90	0.8
72.0	52.1	11.6	1.19	0.4

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
3.0	26.7	29.3	37.0	48.7	60.3	69.5	73.3	70.8	62.5	51.1	39.1	30.4
6.0	27.4	29.6	36.9	48.1	59.5	68.6	72.6	70.5	62.7	51.7	40.0	31.3
12.0	28.8	30.3	36.6	47.0	57.8	66.8	71.2	69.8	63.0	52.9	41.7	33.0
24.0	31.5	31.7	36.4	45.1	54.9	63.6	68.4	68.4	63.2	54.7	44.7	36.3
36.0	34.1	33.2	36.6	43.8	52.4	60.6	65.8	66.8	63.1	56.1	47.1	39.2
72.0	40.8	38.2	38.6	42.1	47.6	53.9	59.0	61.8	61.3	57.8	52.1	46.0

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =50.0,BO=24.0,PO=0.54 ,D=.027

EARTH TEMPERATURE STATION FT. COLLINS,COLO.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 50.0 ,BO= 24.0 AND PO= 0.54

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	31.7	31.8	36.4	45.0	54.7	63.3	68.2	68.2	63.2	54.8	44.9	36.6
48.0	36.9	35.1	37.2	42.8	50.1	57.7	63.0	64.9	62.6	57.1	49.5	42.2
72.0	41.2	38.6	38.8	42.1	47.3	53.5	58.6	61.4	61.1	57.9	52.4	46.4
96.0	44.8	41.7	40.8	42.3	45.8	50.6	55.0	58.3	59.2	57.6	54.0	49.3
120.0	47.4	44.4	42.9	43.2	45.3	48.7	52.4	55.6	57.1	56.8	54.6	51.2
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	38.3	36.8	38.6	43.6	50.1	56.8	61.5	63.2	61.2	56.3	49.5	43.1

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	66.3	67.9	68.2	68.5	68.9
48.0	60.9	64.0	64.9	65.5	66.3
72.0	56.2	60.3	61.4	62.3	63.6
96.0	52.8	56.9	58.3	59.3	60.9
120.0	50.6	54.2	55.6	56.7	58.4
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	59.4	62.3	63.2	63.9	64.9

EARTH TEMPERATURE STATION — FT. COLLINS,COLO.
TYPE OF SOIL — LOAM
TYPE OF EARTH SURFACE — SPARSE VEGETATION
DATA PROCESSED BY
DATA SOURCE — CLIMATOLOGICAL DATA

PERIOD OF OBSERVATION — 1960-1961

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
3.0	27.8	31.4	38.5	51.7	61.8	71.1	78.8	77.7	66.1	53.7	38.1	31.9
6.0	28.4	31.8	38.1	53.2	61.7	70.7	78.7	77.9	66.9	54.9	40.3	33.0
12.0	28.8	31.4	36.0	49.6	58.1	66.4	75.0	74.7	65.0	53.9	40.6	33.8
24.0	32.1	33.0	36.5	48.0	55.9	63.4	71.1	71.8	65.4	56.1	44.4	37.2
36.0	34.7	34.5	36.6	46.1	53.7	60.3	68.2	69.9	65.5	57.5	47.3	40.0
72.0	42.3	40.2	40.2	44.2	49.2	54.6	60.6	64.1	63.9	59.3	52.9	46.7

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
3.0	52.5	25.2	C.58	3.6
6.0	53.1	24.7	0.60	3.0
12.0	51.2	22.8	C.66	2.6
24.0	51.3	19.9	0.77	2.1
36.0	51.3	17.8	C.89	1.9
72.0	51.6	12.1	1.21	0.9

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
3.0	24.8	27.6	35.9	48.5	61.2	71.1	75.2	72.5	63.5	51.2	38.3	28.8
6.0	25.6	28.0	35.7	47.8	60.2	70.1	74.4	72.1	63.7	51.9	39.3	29.8
12.0	27.1	28.7	35.5	46.6	58.3	68.1	72.8	71.4	64.1	53.2	41.2	31.8
24.0	30.2	30.3	35.3	44.6	55.0	64.4	69.7	69.7	64.3	55.3	44.5	35.5
36.0	33.1	32.1	35.6	43.1	52.3	61.1	66.7	67.9	64.2	56.7	47.2	38.8
72.0	40.6	37.7	37.9	41.4	47.1	53.7	59.2	62.3	62.0	58.5	52.6	46.2

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =50.0,B0=26.0,PC=0.54 ,D=.025

EARTH TEMPERATURE STATION FT. COLLINS,COLO.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 50.0 ,B0= 26.0 AND P0= 0.54

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	30.2	30.3	35.3	44.6	55.0	64.4	69.7	69.8	64.3	55.2	44.4	35.4
48.0	35.8	33.9	36.1	42.2	50.2	58.3	64.0	66.1	63.7	57.7	49.4	41.6
72.0	40.5	37.6	37.9	41.4	47.1	53.8	59.3	62.4	62.0	58.5	52.6	46.1
96.0	44.3	41.0	40.0	41.7	45.5	50.6	55.5	59.0	59.9	58.3	54.3	49.3
120.0	47.2	43.9	42.3	42.6	44.9	48.6	52.6	56.0	57.7	57.4	55.0	51.3
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	37.3	35.7	37.6	43.0	50.1	57.4	62.5	64.3	62.2	56.9	49.5	42.5

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	67.7	69.4	69.8	70.1	70.5
48.0	61.8	65.2	66.1	66.8	67.7
72.0	56.7	61.1	62.4	63.3	64.7
96.0	53.0	57.5	59.0	60.1	61.8
120.0	50.7	54.6	56.0	57.2	59.1
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	60.2	63.4	64.3	65.1	66.1

EARTH TEMPERATURE STATION — GAINESVILLE,FLA.
TYPE OF SOIL — SAND
TYPE OF EARTH SURFACE — SOD
DATA PROCESSED BY
DATA SOURCE — CLIMATOLOGICAL DATA

PERIOD OF OBSERVATION — 1960-1961

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
1.0	60.4	62.9	69.5	76.2	86.2	86.1	88.1	86.6	83.7	77.7	70.9	61.1
4.0	59.9	61.4	67.7	74.3	80.5	83.5	86.0	85.1	82.2	76.6	69.8	59.9
8.0	59.5	60.3	63.8	72.8	79.3	82.9	85.7	85.0	82.4	76.6	69.8	60.0

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
1.0	75.9	14.0	0.52	2.9
4.0	74.0	13.2	0.59	2.4
8.0	73.3	13.7	0.67	2.8

EARTH TEMPERATURE STATION GAINESVILLE,FLA.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 74.0 ,BO= 10.0 AND PO= 0.60

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	66.5	66.3	68.0	71.5	75.5	79.2	81.4	81.7	79.8	76.5	72.3	68.7
48.0	68.7	67.8	68.5	70.7	73.7	76.9	79.2	80.2	79.4	77.3	74.2	71.1
72.0	70.6	69.3	69.3	70.5	72.6	75.2	77.4	78.7	78.7	77.5	75.3	72.8
96.0	72.0	70.6	70.2	70.7	72.1	74.0	75.9	77.3	77.8	77.3	75.9	74.0
120.0	73.1	71.8	71.1	71.1	71.9	73.3	74.8	76.2	76.9	76.9	76.0	74.7
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	69.3	68.5	69.1	71.0	73.7	76.6	78.6	79.5	78.8	76.9	74.1	71.4

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	80.8	81.5	81.7	81.8	82.0
48.0	78.5	79.8	80.2	80.5	80.8
72.0	76.5	78.2	78.7	79.1	79.6
96.0	75.0	76.8	77.3	77.8	78.5
120.0	74.2	75.6	76.2	76.7	77.4
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	77.9	79.1	79.5	79.8	80.2

EARTH TEMPERATURE STATION	ATHENS,GA.
TYPE OF SOIL	SANDY LOAM
TYPE OF EARTH SURFACE	THIN GRASS
DATA PROCESSED BY	
DATA SOURCE	CLIMATOLOGICAL DATA
PERIOD OF OBSERVATION	1960-1962

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
2.0	44.8	51.7	52.4	60.0	76.0	80.9	83.7	82.4	78.4	70.5	58.7	45.8
4.0	44.1	51.3	51.8	60.0	75.2	79.9	83.2	81.6	77.8	69.5	58.1	46.3
8.0	46.2	52.8	54.1	61.2	75.5	80.6	83.6	83.5	80.0	72.4	60.3	49.4

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
2.0	65.4	20.1	0.66	3.0
4.0	64.9	19.7	0.66	2.9
8.0	66.6	19.1	0.70	2.8

EARTH TEMPERATURE STATION ATHENS,GA.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 67.0 ,BO= 18.0 AND PO= 0.60

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	53.5	53.1	56.3	62.4	69.7	76.4	80.4	80.9	77.5	71.4	64.0	57.5
48.0	57.5	55.9	57.1	61.0	66.4	72.2	76.4	78.1	76.8	72.9	67.3	61.7
72.0	60.8	58.5	58.5	60.7	64.5	69.1	73.0	75.4	75.5	73.3	69.3	64.8
96.0	63.4	61.0	60.1	61.0	63.5	67.0	70.4	73.0	73.9	72.9	70.3	66.9
120.0	65.4	63.0	61.7	61.8	63.2	65.7	68.5	71.0	72.3	72.2	70.7	68.2
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	58.5	57.1	58.2	61.7	66.5	71.6	75.3	78.9	75.7	72.3	67.2	62.3

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	79.3	80.6	80.9	81.1	81.4
48.0	75.0	77.5	78.1	78.6	79.3
72.0	71.4	74.5	75.4	76.1	77.1
96.0	68.9	72.0	73.0	73.8	75.0
120.0	67.3	69.9	71.0	71.8	73.1
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	74.0	76.2	76.9	77.4	78.2

EARTH TEMPERATURE STATION	TIFTON,GA
TYPE OF SOIL	LOAMY SAND
TYPE OF EARTH SURFACE	GRASS
DATA PROCESSED BY	JEN-HU-CHANG
DATA SOURCE	REFERENCE(5)
	1958
PERIOD OF OBSERVATION	1954-1955

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR											
	J	F	M	A	M	J	J	A	S	O	N	D
3.0	47.5	51.5	65.0	74.8	85.5	90.2	89.5	89.8	83.0	69.8	56.2	49.5
6.0	54.9	57.2	64.8	74.6	78.5	83.5	85.2	86.0	80.0	74.2	62.2	54.5

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
3.0	71.1	22.5	0.40	2.4
6.0	71.4	16.0	0.50	2.1

EARTH TEMPERATURE STATION TIFTON,GA

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 71.0 ,BO= 16.0 AND PO= 0.60

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	59.0	58.7	61.4	67.0	73.4	79.3	82.9	83.3	80.3	74.9	68.3	62.6
48.0	62.5	61.1	62.2	65.7	70.5	75.6	79.3	80.9	79.7	76.2	71.2	66.3
72.0	65.5	63.5	63.4	65.4	68.8	72.9	76.4	78.5	78.5	76.6	73.0	69.1
96.0	67.8	65.6	64.9	65.7	67.9	71.0	74.1	76.3	77.1	76.3	74.0	70.9
120.0	69.5	67.5	66.3	66.4	67.6	69.9	72.3	74.5	75.7	75.6	74.3	72.1
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	63.5	62.2	63.1	66.3	70.6	75.1	78.4	79.8	78.8	75.7	71.2	66.8

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	81.9	83.1	83.3	83.5	83.8
48.0	78.1	80.3	80.9	81.3	81.9
72.0	74.9	77.7	78.5	79.1	80.0
96.0	72.7	75.4	76.3	77.1	78.1
120.0	71.3	73.6	74.5	75.3	76.4
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	77.2	79.2	79.8	80.3	81.0

EARTH TEMPERATURE STATION	TIFTON,GA
TYPE OF SOIL	LOAMY SAND
TYPE OF EARTH SURFACE	GRASS
DATA PROCESSED BY	JEN-HU-CHANG
DATA SOURCE	REFERENCE(5) 1958
PERIOD OF OBSERVATION	1954-1955

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
3.0	47.5	51.5	65.0	74.8	85.5	90.2	89.5	89.8	83.0	69.8	56.2	49.5
6.0	54.9	57.2	64.8	74.6	78.5	83.5	85.2	86.0	80.0	74.2	62.2	54.5

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
3.0	71.1	22.5	C.40	2.4
6.0	71.4	16.0	0.50	2.1

EARTH TEMPERATURE STATION	MOSCOW, IDAHO
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	UNKNOWN
DATA PROCESSED BY	E.P.FITTON
DATA SOURCE	REFERENCE(4)
PERIOD OF OBSERVATION	1898-1901

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
3.0	30.8	28.8	34.4	41.2	51.2	58.0	64.1	67.5	54.6	47.8	40.8	33.8
6.0	31.8	30.2	34.6	42.9	48.6	56.0	63.6	65.4	56.8	50.5	41.6	34.6
9.0	32.8	31.0	35.0	45.9	48.9	54.8	62.9	64.9	57.5	51.8	42.8	36.4
12.0	38.2	32.8	35.4	44.7	48.4	54.8	62.2	64.3	58.1	52.2	43.6	37.4
24.0	35.8	34.5	36.2	44.5	47.5	52.9	59.2	62.5	58.2	53.2	45.8	39.2
36.0	37.8	36.2	37.0	40.5	46.2	50.1	55.9	60.0	57.8	53.8	48.0	41.6
48.0	39.8	38.0	38.0	40.5	45.4	48.8	53.7	58.1	57.1	53.8	48.8	43.4
60.0	40.8	39.5	38.8	40.6	44.6	47.5	51.8	56.3	56.5	54.0	49.6	44.6
72.0	42.8	40.8	39.6	41.5	44.6	47.1	50.6	54.7	55.5	54.0	51.6	46.2

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
3.0	46.2	17.6	0.73	2.2
6.0	46.5	16.6	0.80	1.6
9.0	47.1	15.6	0.82	1.9
12.0	47.8	14.3	0.88	2.1
24.0	47.5	13.1	0.96	1.4
36.0	47.1	11.4	1.15	0.9
48.0	47.2	9.9	1.26	0.8
60.0	47.1	8.8	1.38	0.8
72.0	47.5	7.7	1.52	0.7

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
3.0	30.1	30.3	34.7	42.7	51.5	59.5	63.8	63.7	59.0	51.2	42.0	34.4
6.0	30.8	30.7	34.7	42.3	50.8	58.6	63.1	63.3	59.0	51.6	42.7	35.3
9.0	31.5	31.1	34.8	41.9	50.2	57.8	62.4	62.9	59.0	52.0	43.4	36.1
12.0	32.2	31.6	34.8	41.6	49.5	57.1	61.7	62.5	58.9	52.3	44.1	36.8
24.0	34.8	33.3	35.3	40.5	47.4	54.3	59.1	60.7	58.5	53.4	46.3	39.6
36.0	37.2	35.1	36.0	40.0	45.7	51.9	56.7	58.9	57.8	53.9	48.0	42.0
48.0	39.3	36.8	37.0	39.8	44.5	50.0	54.5	57.1	57.0	54.1	49.3	44.0
60.0	41.2	38.5	38.0	39.9	43.6	48.4	52.6	55.5	56.0	54.1	50.2	45.6
72.0	42.8	40.0	39.1	40.2	43.1	47.1	51.0	53.9	54.9	53.8	50.8	46.8

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =47.0,B0=18.0,PC=0.73 ,D=.019

EARTH TEMPERATURE STATION MOSCOW, IDAHO

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 47.0 ,BO= 18.0 AND PO= 0.73

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	34.2	32.9	35.1	40.7	47.8	54.9	59.7	61.1	58.6	53.1	45.8	39.0
48.0	38.3	36.0	36.5	39.8	45.0	50.9	55.5	58.0	57.4	54.1	48.7	43.1
72.0	41.6	38.9	38.3	39.9	43.4	48.0	52.2	55.1	55.7	54.0	50.4	45.9
96.0	44.2	41.5	40.2	40.6	42.8	46.1	49.6	52.5	53.9	53.4	51.1	47.8
120.0	46.0	43.5	42.0	41.6	42.7	45.1	47.8	50.4	52.1	52.4	51.2	48.9
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	39.3	37.2	37.6	40.6	45.2	50.4	54.6	56.8	56.3	53.3	48.5	43.5

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	59.3	60.8	61.1	61.4	61.8
48.0	54.6	57.3	58.0	58.5	59.3
72.0	50.9	54.1	55.1	55.8	56.9
96.0	48.4	51.5	52.5	53.3	54.6
120.0	47.0	49.4	50.4	51.3	52.6
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	53.7	56.1	56.8	57.3	58.2

EARTH TEMPERATURE STATION	ARGONNE, ILLINOIS
TYPE OF SOIL	SANDY CLAY
TYPE OF EARTH SURFACE	PASTURE GRASS
DATA PROCESSED BY	J.E.CARSON
DATA SOURCE	REFERENCE(10) 1963
PERIOD OF OBSERVATION	1953-1955

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
0.	24.0	29.3	33.6	49.4	57.4	68.9	73.6	71.3	64.1	53.2	37.6	26.4
0.4	31.7	32.5	37.6	50.1	60.7	72.0	78.0	76.0	67.2	56.5	42.6	33.7
3.9	31.8	32.1	36.5	48.9	59.7	71.3	77.1	75.2	66.6	56.4	42.5	33.6
7.9	32.9	32.5	36.4	47.8	58.1	69.2	75.2	74.1	66.8	57.3	44.2	35.0
19.7	35.8	34.5	37.0	45.7	55.0	64.8	70.9	71.6	66.7	59.1	47.9	38.9
39.4	40.0	37.9	38.6	43.9	51.6	59.5	65.9	68.1	66.0	60.6	52.2	44.5
120.0	50.3	47.7	45.8	45.3	47.0	50.1	53.9	57.3	59.2	59.2	57.3	54.1
348.0	52.3	52.4	52.5	51.9	51.5	51.2	50.6	50.7	51.0	51.3	51.6	52.2

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
0.	49.2	24.7	C.60	3.2
0.4	53.3	23.7	C.65	1.9
3.9	52.8	23.4	0.66	2.1
7.9	52.6	22.2	C.72	1.8
19.7	52.4	19.1	0.86	1.4
39.4	52.5	15.3	1.07	1.0
120.0	52.3	7.0	1.85	0.5
348.0	51.6	0.9	4.08	0.3

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
0.	28.3	29.4	35.8	46.7	58.4	68.5	73.6	72.7	65.7	55.1	43.0	33.4
0.4	28.4	29.4	35.8	46.6	58.3	68.3	73.5	72.6	65.8	55.2	43.1	33.5
3.9	29.3	29.9	35.8	46.0	57.3	67.2	72.5	72.1	65.8	55.8	44.1	34.6
7.9	30.3	30.5	35.7	45.4	56.3	66.1	71.5	71.6	65.9	56.4	45.2	35.8
19.7	33.2	32.3	34.0	44.0	53.6	62.8	68.6	69.8	65.7	57.9	47.9	39.1
39.4	37.7	35.3	37.0	42.5	50.1	58.2	64.1	66.6	64.8	59.4	51.5	43.7
120.0	49.3	46.1	44.2	44.0	45.7	48.8	52.5	55.8	57.8	58.0	56.2	53.1
348.0	51.7	51.8	51.6	51.3	50.9	50.6	50.3	50.2	50.4	50.7	51.1	51.4

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =51.0,BO=23.0,PC=0.70 ,D=.026

EARTH TEMPERATURE STATION ARGONNE, ILLINOIS

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 51.0 ,B0= 23.0 AND P0= 0.70

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	34.4	33.0	36.2	43.5	52.6	61.6	67.4	69.0	65.6	58.4	48.9	40.3
48.0	39.6	36.9	37.7	42.2	48.9	56.3	62.2	65.1	64.1	59.7	52.8	45.6
72.0	43.9	40.5	39.9	42.2	46.7	52.6	57.9	61.4	62.1	59.8	55.0	49.3
96.0	47.2	43.8	42.2	43.0	45.8	50.2	54.6	58.2	59.8	59.0	56.0	51.8
120.0	49.6	46.4	44.5	44.2	45.7	48.7	52.2	55.5	57.6	57.8	56.2	53.2
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	40.9	38.4	39.2	43.2	49.1	55.7	60.9	63.6	62.7	58.8	52.6	46.2

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	66.7	68.5	69.0	69.3	69.8
48.0	60.9	64.2	65.1	65.8	66.7
72.0	56.2	60.2	61.4	62.3	63.7
96.0	53.0	56.9	58.2	59.3	60.9
120.0	51.1	54.3	55.5	56.6	58.3
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	59.7	62.6	63.6	64.3	65.3

EARTH TEMPERATURE STATION	LEMONT, ILLINOIS
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	GRASS
DATA PROCESSED BY	JEN-HU-CHANG
DATA SOURCE	REFERENCE(5) 1958
PERIOD OF OBSERVATION	1952-1954

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
0.4	31.2	32.8	37.8	48.9	59.9	73.4	76.2	75.1	66.5	57.4	42.4	33.8
3.9	31.3	32.4	36.8	47.5	58.7	72.9	75.8	74.7	65.9	57.5	43.3	34.0
7.9	32.4	32.8	36.8	46.4	57.1	70.4	74.2	73.4	66.1	58.2	45.0	35.6
19.7	35.2	34.8	37.2	44.8	54.0	65.6	70.6	71.0	66.3	59.6	48.6	39.4
39.4	39.8	37.8	38.7	43.4	50.6	59.8	65.7	67.6	65.8	60.6	52.0	44.4
120.0	50.2	47.4	45.8	45.2	46.6	49.7	53.5	56.8	58.7	58.6	56.0	53.6
348.0	52.2	52.2	52.1	51.8	51.3	51.0	50.1	50.2	50.5	50.8	51.4	51.9

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
0.4	53.1	23.4	C.66	1.4
3.9	52.7	23.2	0.69	1.5
7.9	52.5	21.9	C.74	1.3
19.7	52.4	19.0	C.88	0.9
39.4	52.2	15.3	1.08	0.6
120.0	51.9	6.8	1.84	0.4
348.0	51.3	1.0	4.14	0.1

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
0.4	29.2	30.9	37.7	48.8	60.4	70.1	74.7	73.2	65.9	55.0	43.1	33.8
3.9	30.1	31.3	37.6	48.2	59.5	69.1	73.8	72.8	66.0	55.6	44.0	34.8
7.9	31.0	31.7	37.5	47.5	58.5	67.9	72.9	72.3	66.1	56.3	45.0	35.9
19.7	33.6	33.2	37.5	46.0	55.8	64.9	70.2	70.8	66.1	57.8	47.7	39.0
39.4	37.7	36.0	38.2	44.3	52.3	60.4	66.1	68.1	65.6	59.5	51.3	43.4
120.0	49.3	46.1	44.4	44.7	46.9	50.6	54.5	57.9	59.6	59.2	56.9	53.3
348.0	53.0	52.9	52.6	52.2	51.7	51.3	51.1	51.1	51.4	51.8	52.4	52.7

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =52.0,BO=23.0,PO=0.65 ,D=.030

EARTH TEMPERATURE STATION LEMONT, ILLINOIS

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 52.0 ,BD= 23.0 AND PO= 0.66

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	35.1	34.1	37.6	45.2	54.3	63.1	68.7	69.9	66.1	58.7	49.2	40.7
48.0	40.3	37.8	38.9	43.6	50.4	57.8	63.5	66.2	64.9	60.3	53.2	46.0
72.0	44.6	41.4	41.0	43.5	48.2	54.0	59.2	62.6	63.0	60.5	55.6	49.9
96.0	47.9	44.6	43.2	44.1	47.1	51.5	55.9	59.4	60.8	59.9	56.7	52.4
120.0	50.3	47.2	45.4	45.2	46.9	50.0	53.5	56.8	58.7	58.8	57.0	54.0
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	41.6	39.4	40.4	44.6	50.6	57.2	62.2	64.6	63.5	59.4	53.1	46.7

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	67.7	69.5	69.9	70.2	70.7
48.0	62.0	65.3	66.2	66.8	67.7
72.0	57.4	61.4	62.6	63.5	64.8
96.0	54.1	58.1	59.4	60.4	62.0
120.0	52.2	55.5	56.8	57.8	59.5
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	60.8	63.7	64.6	65.3	66.3

EARTH TEMPERATURE STATION	URBANA, ILLINOIS
TYPE OF SOIL	SILT LOAM
TYPE OF EARTH SURFACE	BLUEGRASS SOD
DATA PROCESSED BY	
DATA SOURCE	CLIMATOLOGICAL DATA
PERIOD OF OBSERVATION	1960-1962

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
4.0	33.7	33.4	38.4	50.7	63.0	73.1	77.0	76.8	71.4	62.7	46.8	35.6
8.0	34.4	34.2	38.3	49.8	61.6	71.6	75.9	73.4	71.5	60.0	48.1	37.4

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
4.0	55.4	23.5		2.9
8.0	54.8	22.0		2.5

EARTH TEMPERATURE STATION URBANA, ILLINOIS

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 53.0 ,BO= 25.0 AND PO= 0.62

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	34.4	33.7	37.8	46.3	56.3	65.7	71.5	72.3	67.8	59.5	49.2	40.2
48.0	39.9	37.5	39.1	44.4	51.9	59.9	65.9	68.5	66.8	61.5	53.7	46.0
72.0	44.6	41.3	41.1	44.0	49.3	55.7	61.2	64.7	64.8	61.9	56.4	50.2
96.0	48.2	44.7	43.4	44.6	48.0	52.8	57.6	61.2	62.6	61.4	57.8	53.1
120.0	50.9	47.6	45.7	45.7	47.6	51.1	54.9	58.4	60.3	60.3	58.2	54.8
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	41.4	39.2	40.6	45.4	52.0	59.1	64.4	66.8	65.2	60.5	53.6	46.7

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	70.1	71.9	72.3	72.7	73.1
48.0	64.1	67.5	68.5	69.1	70.1
72.0	59.1	63.4	64.7	65.6	67.0
96.0	55.5	59.8	61.2	62.4	64.1
120.0	53.4	57.0	58.4	59.6	61.4
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	62.6	65.8	66.8	67.5	68.6

EARTH TEMPERATURE STATION	URBANA, ILLINOIS
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	UNKNOWN
DATA PROCESSED BY	E.M.FITTON
DATA SOURCE	REFERENCE(4)
PERIOD OF OBSERVATION	1913-1915

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
1.0	29.2	29.5	39.8	51.0	63.0	72.6	78.2	76.2	69.0	55.5	42.2	32.1
3.0	31.0	30.6	39.5	50.6	62.2	72.2	77.8	75.8	69.0	56.8	43.0	33.4
6.0	32.6	31.5	39.3	49.2	60.5	70.5	75.8	74.8	68.8	57.0	44.0	35.0
9.0	33.2	33.0	39.2	48.7	59.8	69.4	74.7	74.0	68.6	57.4	45.2	36.0
12.0	34.0	33.2	38.6	48.4	58.8	68.0	73.8	73.2	68.2	58.0	46.2	37.4
24.0	37.6	37.1	38.6	47.1	55.4	62.6	68.5	69.7	66.7	59.5	50.6	42.7
36.0	41.0	38.8	40.1	46.0	53.6	60.3	66.0	67.8	66.1	60.7	53.0	45.8

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
1.0	53.3	25.0	0.62	0.9
3.0	53.6	24.2	0.64	0.9
6.0	53.4	22.7	0.69	0.9
9.0	53.4	21.7	0.71	0.7
12.0	53.2	20.9	0.75	0.6
24.0	53.1	16.8	0.91	0.5
36.0	53.3	14.6	1.04	0.3

EARTH TEMPERATURE STATION URBANA,ILLINOIS

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 55.0 ,B0= 24.0 AND PO= 0.60

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	37.0	36.5	40.7	48.9	58.5	67.5	72.9	73.5	69.0	60.9	51.0	42.4
48.0	42.3	40.1	41.7	47.0	54.2	61.9	67.5	69.9	68.1	62.9	55.4	48.0
72.0	46.7	43.7	43.6	46.6	51.7	57.8	63.1	66.3	66.3	63.4	58.1	52.1
96.0	50.2	47.0	45.8	47.0	50.3	55.0	59.6	63.0	64.2	62.9	59.4	54.9
120.0	52.8	49.7	48.0	48.0	50.0	53.3	57.0	60.3	62.1	61.9	59.9	56.6
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	43.7	41.8	43.2	47.9	54.[illegible]	61.	66.1	68.2	66.6	62.0	55.3	48.8

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	71.4	73.1	73.5	73.8	74.2
48.0	65.7	69.0	69.9	70.5	71.4
72.0	60.9	65.1	66.3	67.2	68.5
96.0	57.5	61.6	63.0	64.1	65.7
120.0	55.4	58.9	60.3	61.4	63.1
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	64.3	67.3	68.2	68.9	70.0

EARTH TEMPERATURE STATION	WEST LAFAYETTE, IND
TYPE OF SOIL	SILT LOAM
TYPE OF EARTH SURFACE	FESQUE GRASS
DATA PROCESSED BY	
DATA SOURCE	CLIMATOLOGICAL DATA
PERIOD OF OBSERVATION	1962

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
2.0				48.0	66.7	74.5	74.3	75.6	66.2	57.0	42.1	30.8
4.0	29.3	29.5	33.7	46.5	64.4	72.5		73.7	66.5	57.7	43.0	32.1
8.0				47.4	63.5	71.4	72.5	73.7	66.7	58.8	45.6	35.9

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
2.0	52.7	25.2	C.60	2.6
4.0	52.5	25.4	0.67	1.9
8.0	53.4	21.9	C.69	2.0

EARTH TEMPERATURE STATION WEST LAFAYETTE, IND

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 52.0 ,BO= 26.0 AND PO= 0.60

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	32.5	32.0	36.5	45.4	55.8	65.5	71.3	72.0	67.2	58.4	47.6	38.3
48.0	38.2	35.9	37.6	43.4	51.2	59.5	65.5	68.1	66.2	60.5	52.4	44.4
72.0	43.0	39.8	39.7	42.9	48.4	55.1	60.7	64.2	64.3	61.1	55.3	48.8
96.0	46.8	43.3	42.0	43.4	47.0	52.0	57.0	60.7	62.0	60.6	56.8	51.9
120.0	49.6	46.2	44.4	44.5	46.5	50.2	54.2	57.7	59.7	59.5	57.3	53.8
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	39.8	37.7	39.2	44.3	51.3	58.7	64.0	66.3	64.6	59.6	52.4	45.2

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	69.8	71.6	72.0	72.4	72.8
48.0	63.6	67.2	68.1	68.8	69.8
72.0	58.4	62.9	64.2	65.2	66.6
96.0	54.7	59.2	60.7	61.8	63.6
120.0	52.5	56.2	57.7	58.9	60.8
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	62.0	65.3	66.3	67.1	68.2

EARTH TEMPERATURE STATION — BURLINGTON, IOWA
TYPE OF SOIL — SILTY LOAM
TYPE OF EARTH SURFACE — CULTIVETED
DATA PROCESSED BY
DATA SOURCE — CLIMATOLOGICAL DATA

PERIOD OF OBSERVATION — 1960-1962

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
1.0	30.1	30.9	36.9	56.1	71.5	81.3	84.7	86.4	74.7	61.0	43.7	31.6
2.2	29.8	30.8	36.9	56.8	72.1	82.5	86.2	87.8	76.1	63.1	44.4	31.7
4.0	30.6	31.2	36.8	55.6	70.9	81.2	85.1	86.5	75.7	62.2	44.5	32.2
8.0	31.8	31.4	35.7	51.4	66.2	75.7	81.1	83.7	74.7	62.1	46.1	34.4
20.0	35.2	33.0	35.3	44.9	58.6	68.2	73.1	75.0	71.7	61.7	48.9	39.6
40.0	41.5	38.5	38.4	43.1	54.0	62.7	67.7	71.9	71.0	64.2	54.6	45.9
72.0	47.2	43.2	42.2	42.8	47.4	53.9	60.5	65.2	67.1	64.4	59.7	52.6

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
1.0	57.5	29.9	0.61	3.4
2.2	58.3	30.7	0.62	3.3
4.0	57.9	29.8	0.63	3.2
8.0	56.3	27.2	0.72	2.8
20.0	53.9	21.8	0.88	2.1
40.0	54.6	17.3	1.11	1.9
72.0	54.0	12.5	1.54	1.0

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
1.0	24.4	27.5	37.2	51.9	66.8	78.6	83.6	80.6	70.2	55.8	40.5	29.2
2.2	24.8	27.7	37.1	51.6	66.3	78.0	83.1	80.4	70.3	56.2	41.1	29.8
4.0	25.5	28.0	36.9	51.0	65.5	77.2	82.5	80.1	70.5	56.7	41.8	30.6
8.0	26.9	28.7	36.7	49.9	63.8	75.4	81.0	79.4	70.7	57.9	43.5	32.4
20.0	31.0	30.9	36.5	47.2	59.4	70.4	76.8	77.1	71.0	60.6	48.0	37.4
40.0	37.4	35.1	37.6	44.6	53.9	63.6	70.4	72.9	70.2	63.2	53.6	44.3
72.0	45.6	41.7	41.1	43.9	49.2	56.1	62.2	66.2	66.9	64.1	58.4	51.8

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =54.0,BO=30.0,PO=0.57 ,D=.019

EARTH TEMPERATURE STATION BURLINGTON, IOWA

CALCULATED EARTH TEMPERATURES AT SELECTED LEPTHS
FOR DIFFUSIVITY=0.025, A= 54.0 ,BO= 30.0 AND PO= 0.57

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	31.3	31.1	36.6	47.1	59.1	70.1	76.5	77.0	71.0	60.7	48.3	37.7
48.0	37.8	35.4	37.7	44.5	53.6	63.1	69.9	72.6	70.1	63.4	53.9	44.7
72.0	43.4	39.8	39.9	43.8	50.2	58.0	64.4	68.2	68.0	64.2	57.4	49.9
96.0	47.7	43.8	42.5	44.2	48.5	54.4	60.0	64.2	65.5	63.7	59.3	53.5
120.0	51.0	47.2	45.2	45.4	47.9	52.2	56.8	60.8	62.9	62.6	59.9	55.8
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	39.6	37.5	39.5	45.5	53.7	62.1	68.2	70.5	68.3	62.3	53.9	45.8

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	74.5	76.5	77.0	77.3	77.8
48.0	67.5	71.5	72.6	73.4	74.5
72.0	61.6	66.7	68.2	69.3	70.9
96.0	57.3	62.5	64.2	65.5	67.5
120.0	54.7	59.1	60.8	62.2	64.3
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	65.7	69.4	70.5	71.4	72.7

EARTH TEMPERATURE STATION — MANHATTAN,KANSAS
TYPE OF SOIL — SILTY CLAY LOAM
TYPE OF EARTH SURFACE — BLUE GRASS
DATA PROCESSED BY
DATA SOURCE — CLIMATOLOGICAL DATA

PERIOD OF OBSERVATION — 1960-1962

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
4.0	29.5	32.9	39.6	51.4	66.2	76.5	80.0	79.4	71.0	60.3	45.3	36.0
48.0	42.4	40.1	41.8	46.9	55.0	64.0	68.3	70.6	69.6	64.7	57.0	49.5
72.0	47.3	44.2	44.0	46.6	52.3	60.1	63.5	66.5	67.1	64.4	59.4	53.5
96.0	51.7	46.2	45.2	46.3	50.3	56.7	59.7	63.1	64.3	63.0	59.6	54.9

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
4.0	55.8	25.5	0.66	2.1
48.0	56.0	15.5	1.10	1.3
72.0	55.8	11.8	1.33	1.1
96.0	55.2	9.4	1.54	1.2

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
4.0	30.2	32.0	39.4	51.5	64.2	74.7	79.7	78.1	70.0	58.3	45.2	35.2
48.0	41.1	39.3	40.8	46.1	53.6	61.8	67.9	70.6	69.1	63.8	56.0	48.1
72.0	46.3	43.4	43.0	45.8	50.9	57.3	62.9	66.5	66.9	64.1	58.8	52.5
96.0	50.6	47.0	45.6	46.5	49.7	54.4	59.2	62.9	64.5	63.4	60.1	55.5

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =55.0,B0=26.0,PC=0.61 ,D=.022

EARTH TEMPERATURE STATION MANHATTAN,KANSA

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 55.0 ,B0= 26.0 AND P0= 0.61

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	35.6	34.9	39.3	48.2	58.6	68.4	74.3	75.1	70.3	61.6	50.8	41.5
48.0	41.3	38.9	40.6	46.2	54.0	62.3	68.5	71.1	69.2	63.7	55.6	47.5
72.0	46.1	42.8	42.6	45.8	51.3	57.9	63.6	67.2	67.3	64.2	58.4	52.0
96.0	49.9	46.3	45.0	46.3	49.9	54.9	59.9	63.6	65.0	63.6	59.9	55.0
120.0	52.7	49.3	47.4	47.4	49.5	53.1	57.1	60.7	62.6	62.5	60.4	56.8
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	42.8	40.7	42.2	47.2	54.1	61.5	67.0	69.3	67.7	62.7	55.5	48.4

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	72.8	74.6	75.1	75.4	75.9
48.0	66.5	70.1	71.1	71.8	72.8
72.0	61.4	65.8	67.2	68.2	69.6
96.0	57.7	62.1	63.6	64.8	66.5
120.0	55.4	59.2	60.7	61.9	63.8
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	65.0	68.3	69.3	70.1	71.2

EARTH TEMPERATURE STATION	LEXINGTON,KY.
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	UNKNOWN
DATA PROCESSED BY	E.M.FITTON
DATA SOURCE	REFERENCE(4)
PERIOD OF OBSERVATION	1922-1927

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
3.0	32.7	35.5	42.1	56.0	62.8	74.6	77.1	76.7	73.1	58.3	45.6	39.2
4.0	20.4	17.3	35.4	49.8	55.6	69.4	75.4	74.6	63.3	55.8	37.6	24.4
18.0	36.3	35.9	41.5	52.0	57.5	67.8	70.6	73.4	70.2	59.8	49.1	41.1
36.0	41.8	40.5	41.0	50.3	56.2	65.8	70.5	73.4	68.8	62.0	53.9	47.5

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
3.0	56.3	22.6	C.64	1.8
4.0	48.4	28.0	C.64	3.5
18.0	54.7	18.8	C.79	1.5
36.0	56.3	15.8	0.94	0.8

EARTH TEMPERATURE STATION LEXINGTON,KY.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 55.0 ,BO= 23.0 AND PO= 0.60

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	37.7	37.3	41.3	49.2	58.4	67.0	72.1	72.7	68.4	60.7	51.1	42.9
48.0	42.8	40.8	42.3	47.3	54.3	61.6	67.0	69.2	67.5	62.5	55.4	48.3
72.0	47.1	44.2	44.1	46.9	51.8	57.7	62.7	65.8	65.8	63.0	57.9	52.2
96.0	50.4	47.3	46.2	47.4	50.5	55.0	59.4	62.7	63.8	62.6	59.3	54.9
120.0	52.9	49.9	48.3	48.3	50.2	53.4	56.9	60.1	61.6	61.6	59.7	56.6
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	44.2	42.3	43.7	48.2	54.4	60.9	65.7	67.7	66.1	61.7	55.3	49.0

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	70.7	72.3	72.7	73.0	73.4
48.0	65.2	68.4	69.2	69.9	70.7
72.0	60.7	64.6	65.8	66.7	67.9
96.0	57.4	61.4	62.7	63.7	65.2
120.0	55.4	58.8	60.1	61.1	62.8
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	63.9	66.8	67.7	68.3	69.3

EARTH TEMPERATURE STATION LEXINGTON,KY.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 55.0 ,BO= 23.0 AND PO= 0.60

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	37.7	37.3	41.3	49.2	58.4	67.0	72.1	72.7	68.4	60.7	51.1	42.9
48.0	42.8	40.8	42.3	47.3	54.3	61.6	67.0	69.2	67.5	62.5	55.4	48.3
72.0	47.1	44.2	44.1	46.9	51.8	57.7	62.7	65.8	65.8	63.0	57.9	52.2
96.0	50.4	47.3	46.2	47.4	50.5	55.0	59.4	62.7	63.8	62.6	59.3	54.9
120.0	52.9	49.9	48.3	48.3	50.2	53.4	56.9	60.1	61.8	61.6	59.7	56.6
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	44.2	42.3	43.7	48.2	54.4	60.9	65.7	67.7	66.1	61.7	55.3	49.0

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	70.7	72.3	72.7	73.0	73.4
48.0	65.2	68.4	69.2	69.9	70.7
72.0	60.7	64.6	65.8	66.7	67.9
96.0	57.4	61.4	62.7	63.7	65.2
120.0	55.4	58.8	60.1	61.1	62.8
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	63.9	66.8	67.7	68.3	69.3

EARTH TEMPERATURE STATION	LEXINGTON,KY
TYPE OF SOIL	SILTY CLAY
TYPE OF EARTH SURFACE	SOD
DATA PROCESSED BY	E.B.PENROD
DATA SOURCE	REFERENCE(8,9)
PERIOD OF OBSERVATION	1952-1956

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
0.	37.2	40.1	46.7	56.2	68.7	79.1	82.6	78.8	73.1	60.4	45.6	38.5
24.0	42.1	42.0	46.0	51.5	60.8	69.4	74.5	74.6	72.2	64.7	53.9	45.5
48.0	48.8	46.4	47.0	49.6	54.9	61.5	67.0	69.5	69.4	66.5	60.6	54.0
72.0	50.8	48.0	47.5	49.4	53.6	59.4	64.5	67.6	68.3	66.4	61.8	56.0
96.0	54.0	50.8	48.9	49.8	52.4	56.7	61.2	64.4	66.3	65.7	63.0	58.8
120.0	56.4	53.5	51.0	50.7	52.0	55.1	58.8	61.9	64.1	64.5	63.2	60.3

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
0.	59.0	23.2	0.56	3.0
24.0	58.2	17.2	0.85	2.0
48.0	58.0	12.0	1.26	1.6
72.0	57.8	10.6	1.42	1.3
96.0	57.7	8.7	1.68	1.3
120.0	57.6	7.0	1.94	1.2

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
0.	36.5	37.0	42.7	52.8	64.0	74.0	79.4	79.1	72.9	63.0	51.4	41.9
24.0	42.2	40.6	43.3	50.1	58.8	67.6	73.6	75.4	72.5	65.7	56.7	48.3
48.0	47.2	44.3	44.9	49.1	55.5	62.8	68.6	71.7	71.0	66.8	60.2	53.1
72.0	51.2	47.8	47.0	49.2	53.6	59.3	64.6	68.2	68.9	66.8	62.1	56.6
96.0	54.3	50.9	49.3	50.0	52.8	57.1	61.5	65.1	66.7	66.0	63.1	58.9
120.0	56.6	53.4	51.5	51.1	52.7	55.7	59.2	62.6	64.6	64.8	63.2	60.3

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =58.0,BO=22.0,PC=0.75 ,D=.027

EARTH TEMPERATURE STATION LEXINGTON,KY

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 58.0 ,BO= 22.0 AND PO= 0.75

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
	MONTH OF YEAR											
24.0	42.5	40.7	43.3	50.0	58.7	67.4	73.3	75.3	72.4	65.8	56.9	48.5
48.0	47.5	44.6	45.1	49.0	55.3	62.5	68.2	71.4	70.8	66.9	60.4	53.4
72.0	51.6	48.2	47.3	49.2	53.4	59.0	64.1	67.8	68.7	66.7	62.3	56.9
96.0	54.7	51.3	49.7	50.1	52.7	56.8	61.1	64.6	66.4	65.8	63.1	59.2
120.0	57.0	53.9	51.9	51.4	52.7	55.5	58.9	62.1	64.2	64.6	63.2	60.4
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	48.7	46.1	46.5	50.0	55.6	62.0	67.1	69.9	69.4	65.9	60.1	53.9

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	73.0	74.	75.3	75.6	76.1
48.0	67.2	70.5	71.4	72.1	73.0
72.0	62.7	66.6	67.8	68.7	70.0
96.0	59.6	63.4	64.6	65.7	67.2
120.0	57.9	60.9	62.1	63.1	64.8
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	66.1	69.0	69.9	70.6	71.6

EARTH TEMPERATURE STATION — UPPER MARLBORO,MD.
TYPE OF SOIL — SANDY LOAM
TYPE OF EARTH SURFACE — BARE
DATA PROCESSED BY
DATA SOURCE — US WEATHER R.C.

PERIOD OF OBSERVATION — 1960-1962

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
2.0	33.0	37.0	40.0	53.0	67.0	74.5	77.0	78.0	73.5	58.0	43.3	34.0
3.9	33.0	36.5	40.0	53.0	66.5	74.5	77.0	78.0	74.5	58.7	44.3	34.7
7.8	34.0	37.0	41.0	53.0	67.5	73.0	76.5	77.5	74.5	59.7	46.0	36.0
19.7	35.5	36.5	40.0	52.0	66.5	72.5	75.5	76.5	74.5	60.7	48.0	38.3
39.4	38.5	36.5	39.0	48.0	60.5	67.0	70.0	72.0	71.0	62.7	52.7	43.5
59.1	42.5	39.0	40.0	47.0	58.0	64.0	67.0	69.5	69.5	64.3	56.0	48.0

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
2.0	55.8	24.1	C.60	2.9
3.9	55.9	24.1	0.62	2.9
7.8	56.4	23.2	C.64	2.8
19.7	56.5	22.2	0.70	2.4
39.4	55.3	18.3	C.90	2.0
59.1	55.6	15.5	1.05	1.9

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
2.0	31.4	34.1	42.2	54.4	66.7	76.5	80.5	78.0	69.3	57.4	44.7	35.4
3.9	31.8	34.3	42.1	54.1	66.2	76.0	80.1	77.8	69.4	57.7	45.2	35.9
7.8	32.6	34.6	41.9	53.4	65.2	74.9	79.3	77.4	69.6	58.4	46.2	37.0
19.7	35.1	35.9	41.6	51.6	62.5	71.9	76.8	76.2	70.0	60.2	49.0	40.0
39.4	38.9	38.1	41.8	49.5	58.7	67.4	72.9	73.9	69.9	62.4	52.9	44.5
59.1	42.5	40.6	42.5	48.2	55.8	63.7	69.3	71.4	69.3	63.7	55.8	48.2

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =56.0,B0=25.0,P0=0.56 ,D=.038

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EARTH TEMPERATURE STATION UPPER MARLBORO,MD.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 56.0 ,BO= 25.0 AND PO= 0.56

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
24.0	37.0	36.9	41.6	50.4	60.5	69.6	74.8	75.1	70.0	61.4	51.0	42.3
48.0	42.5	40.5	42.5	48.2	55.8	63.7	69.3	71.5	69.3	63.7	55.8	48.1
72.0	47.0	44.1	44.3	47.5	53.0	59.4	64.7	67.8	67.7	64.4	58.7	52.5
96.0	50.7	47.4	46.4	47.9	51.5	56.4	61.1	64.5	65.6	64.1	60.3	55.5
120.0	53.4	50.3	48.6	48.8	51.0	54.5	58.4	61.7	63.4	63.1	60.9	57.4
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	43.9	42.2	44.0	49.1	55.9	62.9	67.9	69.8	67.8	62.8	55.8	49.0

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	73.0	74.7	75.1	75.4	75.8
48.0	67.3	70.6	71.5	72.1	73.0
72.0	62.4	66.6	67.8	68.8	70.1
96.0	58.8	63.1	64.5	65.6	67.3
120.0	56.6	60.3	61.7	62.9	64.7
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	65.7	68.8	69.8	70.5	71.5

EARTH TEMPERATURE STATION	EAST LANSING,MICH.
TYPE OF SOIL	CLAY
TYPE OF EARTH SURFACE	UNKNOWN
DATA PROCESSED BY	E.P.FITTON
DATA SOURCE	REFERENCE(4)
PERIOD OF OBSERVATION	1911-1915

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
2.0	31.9	32.1	33.9	54.4	57.4	67.8	74.4	69.4	66.7	52.9	41.1	32.3
4.0	32.0	32.3	33.7	52.0	55.3	65.5	71.6	68.2	65.5	52.3	41.2	33.0
6.0	31.3	30.9	33.2	45.7	57.2	68.8	73.8	70.5	64.8	52.8	41.2	34.4
12.0	32.7	31.7	32.9	42.3	55.5	67.0	72.2	70.2	64.6	53.5	42.2	36.6
18.0	34.2	32.8	33.3	41.5	54.2	65.3	70.9	69.8	64.9	55.1	43.9	38.2

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
2.0	51.3	21.8	C.62	3.0
4.0	50.3	20.5	C.66	2.6
6.0	50.5	22.1	0.69	1.8
12.0	50.2	20.9	C.77	2.1
18.0	50.4	19.8	0.83	2.0

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EARTH TEMPERATURE STATION EAST LANSING,MICH.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 50.0 ,BO= 24.0 AND PO= 0.60

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
24.0	32.0	31.5	35.7	43.9	53.5	62.5	67.9	68.5	64.0	55.9	46.0	37.4
48.0	37.3	35.1	36.7	42.0	49.2	56.9	62.5	64.9	63.1	57.9	50.4	43.0
72.0	41.7	38.7	38.6	41.6	46.7	52.8	58.1	61.3	61.3	58.4	53.1	47.1
96.0	45.2	42.0	40.8	42.0	45.3	50.0	54.6	58.0	59.2	57.9	54.4	49.9
120.0	47.8	44.7	43.0	43.0	45.0	48.3	52.0	55.3	57.1	56.9	54.9	51.6
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	38.7	36.8	38.2	42.9	49.3	56.1	61.1	63.2	61.6	57.0	50.3	43.8

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	66.4	68.1	68.5	68.8	69.2
48.0	60.7	64.0	64.9	65.5	66.4
72.0	55.9	60.1	61.3	62.2	63.5
96.0	52.5	56.6	58.0	59.1	60.7
120.0	50.4	53.9	55.3	56.4	58.1
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	59.3	62.3	63.2	63.9	65.0

EARTH TEMPERATURE STATION — EAST LANSING,MICH.
TYPE OF SOIL — GRAVEL
TYPE OF EARTH SURFACE — UNKNOWN
DATA PROCESSED BY — E.M.FITTON
DATA SOURCE — REFERENCE(4)

PERIOD OF OBSERVATION — 1911-1915

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
2.0	31.8	32.2	34.3	56.2	58.5	69.8	75.7	70.5	67.7	53.7	41.4	32.3
4.0	32.3	32.7	34.4	54.8	57.8	67.9	74.2	69.4	66.7	53.6	41.7	33.0
6.0	31.2	31.0	33.6	47.6	58.4	70.4	75.0	71.5	65.4	53.2	40.9	34.2
12.0	32.1	31.4	33.5	44.0	56.6	68.7	73.6	71.0	64.7	53.6	41.6	35.8
18.0	33.7	32.8	33.7	42.8	55.0	66.8	72.2	70.4	64.9	54.6	43.1	37.6

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
2.0	52.1	22.6	C.61	3.2
4.0	51.6	21.5	0.62	2.9
6.0	51.1	22.7	C.66	1.8
12.0	50.7	21.7	0.72	2.0
18.0	50.7	20.3	C.79	2.0

EARTH TEMPERATURE STATION EAST LANSING,MICH.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 51.0 ,80= 24.C AND PO= 0.59

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	32.9	32.6	36.8	45.1	54.7	63.6	68.9	69.5	64.9	56.7	46.8	38.2
48.0	38.2	36.1	37.8	43.1	50.4	58.0	63.6	65.9	64.0	58.7	51.2	43.9
72.0	42.6	39.7	39.6	42.6	47.8	53.9	59.1	62.3	62.3	59.3	53.9	48.0
96.0	46.1	42.9	41.8	43.1	46.4	51.1	55.7	59.0	60.2	58.9	55.4	50.8
120.0	48.7	45.6	44.0	44.1	46.0	49.4	53.1	56.3	58.1	57.9	55.8	52.6
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	39.6	37.8	39.3	44.0	50.5	57.3	62.2	64.2	62.6	57.9	51.2	44.6

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	67.4	69.1	69.5	69.8	70.2
48.0	61.7	65.0	65.9	66.5	67.4
72.0	57.0	61.1	62.3	63.2	64.5
96.0	53.6	57.7	59.0	60.1	61.7
120.0	51.5	55.0	56.3	57.4	59.2
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	60.3	63.3	64.2	64.9	65.9

EARTH TEMPERATURE STATION	EAST LANSING,MICH.
TYPE OF SOIL	LOAM
TYPE OF EARTH SURFACE	UNKNOWN
DATA PROCESSED BY	E.W.FITTON
DATA SOURCE	REFERENCE(4)
PERICD OF OBSERVATION	1914-1916

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
2.0	31.3	31.5	33.3	55.2	57.0	67.9	73.4	68.5	67.2	53.4	41.0	32.5
4.0	32.0	32.1	33.9	53.0	56.4	66.4	72.8	68.1	65.9	52.8	41.4	33.6
6.0	30.8	30.4	32.6	45.4	57.0	68.9	74.0	70.6	64.8	52.6	40.7	34.2
12.0	32.7	31.7	32.5	42.0	55.5	67.6	73.0	70.9	65.1	54.1	42.4	36.7
18.0	34.5	33.1	33.1	40.8	53.1	64.3	70.2	69.3	64.5	55.1	44.0	38.6

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
2.0	51.1	21.8	C.63	3.3
4.0	50.8	20.8	0.64	2.7
6.0	50.3	22.4	C.69	1.8
12.0	50.5	21.4	0.78	2.3
18.0	50.2	19.4	C.86	2.1

EARTH TEMPERATURE STATION EAST LANSING,MICH.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 50.0 ,B0= 24.(AND PO= 0.60

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	32.0	31.5	35.7	43.9	53.5	62.5	67.9	68.5	64.0	55.9	46.0	37.4
48.0	37.3	35.1	36.7	42.0	49.2	56.9	62.5	64.9	63.1	57.9	50.4	43.0
72.0	41.7	38.7	38.6	41.6	46.7	52.8	58.1	61.3	61.3	58.4	53.1	47.1
96.0	45.2	42.0	40.8	42.0	45.3	50.0	54.6	58.0	59.2	57.9	54.4	49.9
120.0	47.8	44.7	43.0	43.0	45.0	48.3	52.0	55.3	57.1	56.9	54.9	51.6
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	38.7	36.8	38.2	42.9	49.3	56.1	61.1	63.2	61.6	57.0	50.3	43.8

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	66.4	68.1	68.5	68.8	69.2
48.0	60.7	64.0	64.9	65.5	56.4
72.0	55.9	60.1	61.3	62.2	63.5
96.0	52.5	56.6	58.0	59.1	60.7
120.0	50.4	53.9	55.3	56.4	58.1
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	59.3	62.3	63.2	63.9	65.0

EARTH TEMPERATURE STATION	EAST LANSING,MICH.
TYPE OF SOIL	PEAT
TYPE OF EARTH SURFACE	UNKNOWN
DATA PROCESSED BY	E.M.FITTON
DATA SOURCE	REFERENCE(4)
PERIOD OF OBSERVATION	1911-1915

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
2.0	32.0	31.9	31.9	49.9	56.7	67.5	74.2	69.4	61.9	52.9	40.5	33.3
4.0	31.9	31.7	31.6	46.6	55.0	64.6	71.5	67.5	64.7	51.5	40.7	34.0
6.0	30.8	30.4	31.4	41.1	56.8	68.5	73.9	71.0	65.1	52.9	40.9	34.7
12.0	32.6	31.6	31.9	38.6	54.7	66.9	72.1	71.3	65.6	54.8	42.8	36.6
18.0	35.2	33.7	33.4	37.8	53.2	64.5	70.8	70.3	65.6	56.4	45.2	39.2

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
2.0	50.7	21.9	C.68	2.7
4.0	49.4	20.5	0.71	2.2
6.0	49.9	22.6	C.74	2.5
12.0	50.1	21.5	0.83	2.6
18.0	50.5	19.7	C.90	2.6

EARTH TEMPERATURE STATION EAST LANSING,MICH.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 50.0 ,B0= 24.C AND P0= 0.60

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	32.0	31.5	35.7	43.9	53.5	62.5	67.9	68.5	64.0	55.9	46.0	37.4
48.0	37.3	35.1	36.7	42.0	49.2	56.9	62.5	64.9	63.1	57.9	50.4	43.0
72.0	41.7	38.7	38.6	41.6	46.7	52.8	58.1	61.3	61.3	58.4	53.1	47.1
96.0	45.2	42.0	40.8	42.0	45.3	50.0	54.6	58.0	59.2	57.9	54.4	49.9
120.0	47.8	44.7	43.0	43.0	45.0	48.3	52.0	55.3	57.1	56.9	54.9	51.6
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	38.7	36.8	38.2	42.9	49.3	56.1	61.1	63.2	61.6	57.0	50.3	43.8

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	66.4	68.1	68.5	68.8	69.2
48.0	60.7	64.0	64.9	65.5	66.4
72.0	55.9	60.1	61.3	62.2	63.5
96.0	52.5	56.6	58.0	59.1	60.7
120.0	50.4	53.9	55.3	56.4	58.1
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	59.3	62.3	63.2	63.9	65.0

EARTH TEMPERATURE STATION	EAST LANSING,MICH.
TYPE OF SOIL	SAND
TYPE OF EARTH SURFACE	UNKNOWN
DATA PROCESSED BY	E.M.FITTON
DATA SOURCE	REFERENCE(4)
PERIOD OF OBSERVATION	1911-1915

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR											
	J	F	M	A	M	J	J	A	S	O	N	D
2.0	30.6	32.2	34.3	56.2	58.7	70.0	76.2	70.8	68.2	54.1	41.1	30.2
4.0	31.3	32.7	34.5	54.4	58.1	68.6	75.0	70.0	67.4	54.0	41.5	31.8
6.0	30.5	30.5	33.6	47.7	58.5	69.9	74.5	71.4	65.3	53.0	40.5	33.8
12.0	32.2	31.4	33.4	42.9	56.3	67.8	72.8	70.7	64.5	53.6	41.9	36.0
18.0	34.3	33.0	33.9	42.5	54.4	65.5	71.1	69.9	64.8	55.0	43.8	38.3

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
2.0	52.0	23.3	C.60	3.2
4.0	51.7	22.2	0.62	2.8
6.0	50.9	22.8	C.66	1.6
12.0	50.4	21.4	0.74	2.0
18.0	50.6	19.7	C.82	1.9

EARTH TEMPERATURE STATION — EAST LANSING, MICH.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 50.0 ,B0= 24.0 AND P0= 0.60

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
24.0	32.0	31.5	35.7	43.9	53.5	62.5	67.9	68.5	64.0	55.9	46.0	37.4
48.0	37.3	35.1	36.7	42.0	49.2	56.9	62.5	64.9	63.1	57.9	50.4	43.0
72.0	41.7	38.7	38.6	41.6	46.7	52.8	58.1	61.3	61.3	58.4	53.1	47.1
96.0	45.2	42.0	40.8	42.0	45.3	50.0	54.6	58.0	59.2	57.9	54.4	49.3
120.0	47.8	44.7	43.0	43.0	45.0	48.3	52.0	55.3	57.1	56.9	54.9	51.6
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	38.7	36.8	38.2	42.9	49.3	56.1	61.1	63.2	61.6	57.0	50.3	43.8

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	66.4	68.1	68.5	68.8	69.2
48.0	60.7	64.0	64.9	65.5	66.4
72.0	55.9	60.1	61.3	62.2	63.5
96.0	52.5	56.6	58.0	59.1	60.7
120.0	50.4	53.9	55.3	56.4	58.1
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	59.3	62.3	63.2	63.9	65.0

EARTH TEMPERATURE STATION — ST.PAUL,MINN.
TYPE OF SOIL — SILT LOAM
TYPE OF EARTH SURFACE — SOD
DATA PROCESSED BY
DATA SOURCE — CLIMATOLOGICAL DATA
PERIOD OF OBSERVATION — 1961-1962

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
0.4	25.9	28.3	32.8	43.4	64.3	74.0	77.3	76.4	64.7	54.3	38.0	31.8
1.9	26.1	27.9	32.2	41.8	63.1	75.0	76.9	75.9	64.8	54.5	38.3	32.1
3.9	26.6	27.8	31.8	39.7	60.7	72.6	75.2	74.6	64.5	54.5	38.8	32.7
7.9	27.4	27.8	31.4	34.2	56.6	68.0	72.3	71.8	63.4	53.8	39.3	34.2
15.7	29.9	30.8	31.1	34.0	52.9	63.7	68.2	69.5	63.3	54.4	41.7	35.8
31.5	33.3	30.7	32.0	33.4	48.3	58.9	65.7	68.4	63.6	56.2	43.6	39.7
47.2	37.8	35.5	34.1	34.5	45.2	55.3	62.5	64.8	63.1	57.1	48.6	41.9
62.9	39.5	37.0	35.3	35.2	43.0	52.7	60.1	62.9	62.4	57.4	50.3	43.8
125.9	45.8	43.2	40.9	40.1	40.7	45.7	51.4	55.6	57.7	56.6	53.3	49.5

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
0.4	51.0	26.5	C.64	2.9
1.9	50.9	26.6	0.65	3.1
3.9	50.1	25.6	C.70	3.1
7.9	48.5	23.6	0.78	3.6
15.7	48.3	20.9	C.84	2.8
31.5	47.9	19.1	1.02	2.7
47.2	48.5	16.0	1.15	1.9
62.9	48.4	14.4	1.27	1.7
125.9	48.4	8.8	1.77	1.0

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
0.4	23.3	25.0	32.4	44.5	57.1	67.6	72.6	71.1	63.1	51.3	38.3	28.2
1.9	23.6	25.2	32.4	44.2	56.7	67.2	72.3	70.9	63.1	51.6	38.7	28.7
3.9	24.1	25.5	32.3	43.8	56.1	66.6	71.8	70.6	63.2	51.9	39.3	29.3
7.9	25.1	26.0	32.3	43.2	55.0	65.4	70.8	70.1	63.3	52.6	40.4	30.5
15.7	27.0	27.0	32.2	42.0	53.1	63.1	68.8	69.0	63.4	53.8	42.4	32.7
31.5	30.7	29.3	32.6	40.3	49.8	59.1	65.1	66.7	63.1	55.6	45.7	36.8
47.2	34.0	31.7	33.5	39.3	47.2	55.7	61.8	64.3	62.3	56.6	48.3	40.2
62.9	37.0	34.0	34.6	38.8	45.4	52.8	58.8	62.0	61.3	57.1	50.3	43.1
125.9	45.5	42.0	40.2	40.3	42.5	46.2	50.3	53.9	55.9	55.7	53.4	49.7

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =48.0,BO=25.0,PC=0.65 ,D=.031

EARTH TEMPERATURE STATION ST.PAUL,MINN.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 48.0 ,B0= 25.0 AND P0= 0.65

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	29.6	28.6	32.5	40.7	50.7	60.3	66.3	67.4	63.2	55.1	44.8	35.6
48.0	35.2	32.6	33.9	39.0	46.4	54.5	60.6	63.4	62.0	56.8	49.2	41.4
72.0	39.8	36.4	36.0	38.8	43.9	50.3	55.9	59.5	59.9	57.1	51.8	45.6
96.0	43.4	39.9	38.4	39.5	42.7	47.6	52.3	56.1	57.6	56.5	53.0	48.4
120.0	46.1	42.7	40.8	40.7	42.5	45.9	49.7	53.2	55.3	55.3	53.4	50.1
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	36.6	34.3	35.4	40.0	46.6	53.8	59.2	61.7	60.4	55.9	49.0	42.1

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	65.1	67.0	67.4	67.8	68.3
48.0	58.9	62.5	63.4	64.1	65.1
72.0	53.9	58.3	59.5	60.5	61.9
96.0	50.4	54.7	56.1	57.2	58.9
120.0	48.3	51.8	53.2	54.4	56.2
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	57.5	60.7	61.7	62.5	63.6

EARTH TEMPERATURE STATION — STATE UNIV.MISS.
TYPE OF SOIL — CLAY
TYPE OF EARTH SURFACE — BARE
DATA PROCESSED BY
DATA SOURCE — CLIMATOLOGICAL DATA

PERIOD OF OBSERVATION — 1960-1962

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
2.0	49.4	55.0	54.2	65.1	83.0	85.2	89.5	87.9	82.5	72.3		48.8
4.0	44.1	53.3	56.6	63.1	76.8	79.7	85.7	86.8	82.3	72.7	57.1	47.4
8.0	46.4	53.2	55.5	62.1	75.3	79.4	82.8	83.9	79.9	70.0	54.9	48.9
16.0	46.4	53.9	53.2	61.8	74.4	80.1	84.3	84.2	81.0	72.8		51.4

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
2.0	69.5	21.0	C.60	3.1
4.0	67.5	20.5	0.66	4.0
8.0	66.3	18.8	(.64	3.1
16.0	67.2	18.7	0.74	2.3

EARTH TEMPERATURE STATION STATE UNIV.MISS.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 67.0 ,B0= 21.C AND PO= 0.58

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	51.1	50.9	54.7	62.0	70.4	78.2	82.7	83.1	79.0	71.9	63.2	55.7
48.0	55.7	54.0	55.5	60.2	66.6	73.3	78.1	80.0	78.3	73.7	67.1	60.6
72.0	59.6	57.1	57.1	59.9	64.3	69.7	74.2	76.9	76.8	74.2	69.5	64.2
96.0	62.7	59.9	58.9	60.1	63.1	67.2	71.1	74.1	75.0	73.9	70.7	66.7
120.0	65.0	62.3	60.8	61.0	62.7	65.6	68.9	71.7	73.2	73.0	71.2	68.3
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	57.0	55.4	56.8	61.0	66.6	72.6	76.9	78.6	77.1	72.9	67.1	61.3

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	81.3	82.8	83.1	83.4	83.7
48.0	76.4	79.3	80.0	80.6	81.3
72.0	72.3	75.9	76.9	77.7	78.8
96.0	69.3	72.9	74.1	75.0	76.4
120.0	67.4	70.5	71.7	72.7	74.2
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	75.1	77.8	78.6	79.2	80.1

EARTH TEMPERATURE STATION	FALCETT,MO.
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	SOD
DATA PROCESSED BY	JEN-HU-CHANG
DATA SOURCE	REFERENCE(5)
PERIOD OF OBSERVATION	1951-1952

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
1.0	33.0	33.9	38.7	47.8	64.1	73.8	83.4	81.1	71.4	56.4	43.8	34.4
3.0	33.2	33.6	38.0	46.3	63.0	71.1	79.9	78.3	70.2	55.8	43.6	35.1
6.0	33.8	33.9	37.5	45.2	62.1	69.1	76.7	76.4	69.4	56.5	44.1	36.4
12.0	35.3	35.2	37.5	43.8	61.1	68.0	73.6	74.6	70.2	56.8	46.2	38.6
24.0	37.2	36.0	38.5	44.3	58.0	65.3	71.1	73.6	68.0	59.5	49.2	42.4
48.0	43.2	41.6	41.7	44.8	53.5	60.7	65.4	67.7	66.6	62.6	55.6	48.6
72.0	45.5	44.4	44.2	46.0	48.9	55.6	61.3	64.0	64.7	62.5	57.0	51.4

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
1.0	55.3	25.6	C.66	2.4
3.0	54.1	24.1	0.69	2.2
6.0	53.5	22.7	C.73	2.1
12.0	53.5	21.0	0.78	2.2
24.0	53.7	18.8	C.88	1.3
48.0	54.4	13.7	1.14	0.7
72.0	53.9	10.8	1.37	0.7

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
1.0	34.4	35.7	41.5	51.1	61.1	69.5	73.5	72.4	66.1	56.8	46.4	38.4
3.0	34.9	35.9	41.5	50.7	60.5	68.9	73.0	72.1	66.2	57.1	47.0	39.0
6.0	35.6	36.3	41.4	50.2	59.7	68.0	72.3	71.7	66.2	57.7	47.8	39.9
12.0	37.1	37.1	41.4	49.3	58.2	66.2	70.8	70.9	66.3	58.6	49.4	41.7
24.0	39.9	38.9	41.7	47.9	55.6	63.1	68.0	69.1	66.1	59.9	52.0	44.8
48.0	44.8	42.5	43.1	46.7	52.1	58.2	63.0	65.5	64.8	61.2	55.6	49.7
72.0	48.7	45.9	45.2	46.8	50.3	54.9	59.1	62.1	62.8	61.2	57.5	53.1

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =54.0,BO=20.0,PC=0.65 ,D=.019

EARTH TEMPERATURE STATION FAUCETT,MO.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 54.0 ,HO= 20.0 AND PO= 0.65

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	39.2	38.5	41.6	48.2	56.2	63.8	68.6	69.6	66.2	59.7	51.4	44.1
48.0	43.7	41.7	42.7	46.8	52.8	59.2	64.1	66.3	65.2	61.1	54.9	48.7
72.0	47.5	44.7	44.4	46.6	50.7	55.9	60.4	63.2	63.5	61.3	57.0	52.0
96.0	50.3	47.5	46.3	47.2	49.8	53.6	57.5	60.5	61.7	60.8	58.0	54.3
120.0	52.5	49.8	48.2	48.1	49.6	52.3	55.4	58.2	59.8	59.9	58.3	55.7
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	44.9	43.0	43.9	47.6	52.9	58.6	63.0	65.0	63.9	60.3	54.8	49.3

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	67.7	69.2	69.6	69.8	70.2
48.0	62.8	65.6	66.3	66.9	67.7
72.0	58.7	62.2	63.2	64.0	65.2
96.0	55.9	59.3	60.5	61.4	62.8
120.0	54.2	57.1	58.2	59.1	60.6
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	61.6	64.2	65.0	65.6	66.5

EARTH TEMPERATURE STATION	KANSAS CITY,MO.
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	UNKNOWN
DATA PROCESSED BY	JEN-HU-CHANG
DATA SOURCE	REFERENCE(5)
PERIOD OF OBSERVATION	1950-1952

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
3.9	34.8	41.1	41.8	54.5	70.3	77.7	75.4	75.5	71.2	61.1	48.5	34.5
7.9	35.6	37.8	41.3	52.9	63.4	75.2	73.3	76.6	67.4	58.8	47.6	36.6
11.8	36.9	38.0	40.3	49.8	60.6	70.7	72.2	78.3	66.0	58.9	48.3	38.7
19.7	38.1	38.9	40.2	47.7	58.0	67.0	69.8	69.1	64.9	59.4	49.7	40.8
39.4	39.5	39.7	40.9	47.1	55.4	63.7	67.7	71.2	65.1	60.1	50.6	43.0

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
3.9	57.3	22.3	C.58	3.1
7.9	55.6	21.1	0.63	1.9
11.8	55.0	19.9	C.72	2.1
19.7	53.7	16.8	0.80	1.2
39.4	54.8	15.8	C.90	1.0

EARTH TEMPERATURE STATION KANSAS CITY,MO.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 54.0 ,B0= 22.C AND P0= 0.56

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	37.3	37.2	41.3	49.1	57.9	66.0	70.6	70.8	66.4	58.8	49.6	41.9
48.0	42.1	40.4	42.1	47.1	53.9	60.8	65.7	67.6	65.7	60.8	53.8	47.1
72.0	46.1	43.6	43.7	46.6	51.3	57.0	61.7	64.4	64.3	61.4	56.4	50.9
96.0	49.3	46.5	45.6	46.9	50.0	54.4	58.5	61.5	62.4	61.1	57.8	53.6
120.0	51.7	49.0	47.5	47.7	49.6	52.7	56.1	59.0	60.5	60.3	58.3	55.2
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	43.4	41.9	43.4	47.3	53.9	60.1	64.4	66.1	64.4	60.0	53.8	47.9

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	69.0	70.4	70.8	71.1	71.4
48.0	63.9	66.3	67.6	68.2	69.0
72.0	59.6	63.3	64.4	65.2	66.4
96.0	56.5	60.3	61.5	62.5	63.9
120.0	54.5	57.8	59.0	60.0	61.6
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	62.6	65.3	66.1	66.8	67.7

EARTH TEMPERATURE STATION	SIKESTON,MO.
TYPE OF SOIL	SANDY LOAM
TYPE OF EARTH SURFACE	GRASS
DATA PROCESSED BY	
DATA SOURCE	CLIMATOLOGICAL DATA
PERIOD OF OBSERVATION	1960-1962

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
1.0	36.9	41.1	45.1	57.6	69.8	78.9	83.9	82.8	76.1	64.1	49.6	
3.0	37.3	37.9	45.0	57.5	70.2	79.2	84.2	83.3	76.7	66.0	50.6	
6.0	37.3	39.0	44.9	57.1	69.8	78.7	83.8	82.7	76.0	66.1	50.8	
24.0	37.0	38.3	43.1	51.8	63.1	70.8	75.0	76.4	73.3	65.6	53.6	
72.0	47.0	39.7	44.3	47.7	54.9	61.7	66.7	70.0	70.4	67.4	61.2	54.3

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
1.0	60.6	24.0	0.63	3.2
3.0	61.1	24.0	0.66	3.1
6.0	60.8	23.8	0.66	3.0
24.0	57.9	19.7	0.83	2.3
72.0	57.5	13.6	1.29	1.2

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
1.0	32.3	34.7	42.6	54.9	67.3	77.4	81.7	79.4	70.9	58.9	46.1	36.5
3.0	32.7	34.9	42.5	54.5	66.8	76.8	81.2	79.2	71.0	59.3	46.6	37.1
6.0	33.4	35.2	42.4	53.9	66.0	75.9	80.5	78.9	71.1	59.8	47.5	38.0
24.0	37.3	37.3	42.2	51.3	61.7	71.2	76.6	76.9	71.5	62.5	51.8	42.7
72.0	46.4	43.6	44.3	48.4	54.7	61.8	67.4	70.4	69.6	65.5	59.0	52.1

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =57.0,PO=25.0,PC=0.59 ,D=.034

EARTH TEMPERATURE STATION SIKESTON,MO.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 57.0 ,B0= 25.0 AND P0= 0.59

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	38.2	37.8	42.2	50.9	60.9	70.2	75.7	76.2	71.5	63.0	52.6	43.7
48.0	43.7	41.5	43.3	48.8	56.4	64.3	70.1	72.5	70.5	65.1	57.7	49.6
72.0	48.3	45.2	45.2	48.3	53.6	60.1	65.5	68.8	68.8	65.6	60.1	53.9
96.0	51.9	48.6	47.4	48.7	52.2	57.1	61.9	65.4	66.6	65.2	61.5	56.8
120.0	54.6	51.4	49.7	49.8	51.8	55.3	59.2	62.5	64.4	64.2	62.1	58.6
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	45.2	43.2	44.8	49.7	56.4	63.5	66.7	70.8	69.1	64.2	57.2	50.4

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	74.1	75.8	76.2	76.5	77.0
48.0	68.2	71.6	72.5	73.1	74.1
72.0	63.2	67.5	68.8	69.7	71.1
96.0	59.7	64.0	65.4	66.5	68.2
120.0	57.5	61.1	62.5	63.7	65.5
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	66.7	69.8	70.8	71.5	72.6

EARTH TEMPERATURE STATION	BOZEMAN, MONTANA
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	UNKNOWN
DATA PROCESSED BY	JEN-HU-CHANG
DATA SOURCE	REFERENCE(5)
PERIOD OF OBSERVATION	1916-1920

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
12.0	29.7	29.1	30.2	35.0	44.2	55.4	64.4	62.9	55.4	44.6	35.4	31.5
24.0	31.8	30.7	31.4	34.8	42.8	52.3	60.0	61.4	56.2	47.0	38.6	34.1
36.0	33.5	32.7	32.0	34.1	40.0	49.7	56.1	58.1	55.1	47.6	39.9	35.6
48.0	36.0	34.4	33.6	34.6	38.8	46.1	53.8	57.3	55.2	49.2	42.8	38.3
60.0	37.7	35.7	34.7	35.3	38.8	44.8	51.0	54.2	53.7	49.8	44.4	40.2
90.0	41.2	37.3	37.9	37.4	38.7	42.0	46.6	50.8	51.9	50.0	46.4	43.4
120.0	41.8	39.0	38.5	37.9	38.7	41.7	46.1	50.0	51.4	50.1	46.9	43.9

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
12.0	43.2	17.6	0.79	3.2
24.0	43.5	15.4	0.92	2.4
36.0	42.8	13.1	1.04	2.2
48.0	43.4	11.5	1.21	2.1
60.0	43.4	9.7	1.33	1.4
90.0	43.8	6.9	1.66	1.1
120.0	43.9	6.5	1.74	1.0

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
12.0	28.9	28.4	30.4	38.3	47.5	56.0	61.1	61.6	57.3	49.5	40.0	31.9
24.0	30.1	28.6	30.9	36.7	44.7	52.4	57.7	59.4	56.9	50.9	42.9	35.5
36.0	33.1	30.9	31.8	36.2	42.5	49.5	54.7	57.2	56.0	51.7	45.1	38.4
48.0	35.7	32.9	33.0	36.0	41.0	47.0	52.1	55.0	54.9	51.9	46.7	40.9
60.0	38.0	35.0	34.3	36.1	40.1	45.2	49.8	53.0	53.7	51.8	47.7	42.8
90.0	42.2	39.2	37.6	37.5	39.2	42.3	45.7	48.7	50.5	50.4	48.7	45.7
120.0	44.5	42.2	40.4	39.5	39.8	41.3	43.4	45.8	47.7	48.5	48.2	46.7

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =44.0, B0=21.0, P0=0.68 , D=.015

EARTH TEMPERATURE STATION BOZEMAN, MONTANA

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 44.0 ,BO= 21.0 AND PO= 0.68

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	28.7	27.6	30.6	37.5	45.8	53.9	59.1	60.4	57.1	50.4	41.8	34.0
48.0	33.5	31.1	30.0	36.2	42.3	48.1	54.3	56.9	55.9	51.8	45.4	38.8
72.0	37.4	34.4	33.9	36.1	40.3	45.7	50.4	53.6	54.1	51.9	47.5	42.2
96.0	40.4	37.3	36.0	36.7	39.4	43.4	47.4	50.7	52.0	51.2	48.4	44.5
120.0	42.6	39.7	38.0	37.8	39.2	42.0	45.3	48.2	50.1	50.2	48.6	45.9
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	34.6	32.5	33.3	37.0	42.5	48.5	53.2	55.5	54.6	50.9	45.2	39.4

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	58.4	60.0	60.4	60.7	61.1
48.0	53.1	56.1	56.9	57.5	58.4
72.0	48.8	52.5	53.6	54.4	55.6
96.0	45.9	49.5	50.7	51.6	53.1
120.0	44.1	47.1	48.2	49.2	50.8
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	51.9	54.7	55.5	56.1	57.1

EARTH TEMPERATURE STATION	BOZEMAN, MONTANA
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	UNKNOWN
DATA PROCESSED BY	JEN-HU-CHANG
DATA SOURCE	REFERENCE(5)
PERIOD OF OBSERVATION	1916-1920

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
12.0	29.7	29.1	30.2	35.0	44.2	55.4	64.4	62.9	55.4	44.6	35.4	31.5
24.0	31.8	30.7	31.4	34.8	42.8	52.3	60.0	61.4	56.2	47.0	38.6	34.1
36.0	33.5	32.2	32.0	34.1	40.0	48.7	56.1	58.1	55.1	47.6	39.9	35.6
48.0	36.0	34.4	33.6	34.6	38.8	46.1	53.8	57.3	55.2	49.2	42.8	38.3
60.0	37.7	35.7	34.7	35.3	38.8	44.8	51.0	54.2	53.7	49.8	44.4	40.2
90.0	41.2	39.3	37.9	37.4	38.7	42.0	46.6	50.8	51.9	50.0	46.4	43.4
120.0	41.8	39.9	38.5	37.9	38.7	41.7	46.1	50.0	51.4	50.1	46.9	43.9

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
12.0	43.2	17.6	0.79	3.2
24.0	43.5	15.4	0.92	2.4
36.0	42.8	13.1	1.04	2.2
48.0	43.4	11.5	1.21	2.1
60.0	43.4	9.7	1.33	1.4
90.0	43.8	6.9	1.66	1.1
120.0	43.9	6.5	1.74	1.0

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
12.0	26.8	26.4	30.4	38.3	47.5	56.0	61.1	61.6	57.3	49.5	40.0	31.9
24.0	30.1	28.6	30.9	36.9	44.7	52.4	57.7	59.4	56.9	50.9	42.9	35.5
36.0	33.1	30.8	31.8	36.2	42.5	49.5	54.7	57.2	56.0	51.7	45.1	38.4
48.0	35.7	32.9	33.0	36.0	41.0	47.0	52.1	55.0	54.9	51.9	46.7	40.9
60.0	38.0	35.0	34.3	36.1	40.1	45.2	49.8	53.0	53.7	51.8	47.7	42.8
90.0	42.2	39.2	37.6	37.5	39.2	42.3	45.7	48.7	50.5	50.4	48.7	45.7
120.0	44.5	42.2	40.4	39.5	39.8	41.3	43.4	45.8	47.7	48.5	48.2	46.7

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =44.0,BO=21.0,PC=0.68 ,C=.015

EARTH TEMPERATURE STATION	BOZEMAN, MONTANA
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	UNKNOWN
DATA PROCESSED BY	E.P.FITTON
DATA SOURCE	REFERENCE(4)
PERIOD OF OBSERVATION	1916-1920

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
12.0	29.7	29.1	30.2	35.0	44.2	55.4	64.4	62.9	55.4	44.6	35.4	31.5
24.0	31.9	30.7	31.4	34.8	42.8	52.3	60.0	61.4	56.2	47.0	38.6	34.1
36.0	33.5	32.2	32.0	34.1	40.0	48.7	56.1	58.1	55.1	47.6	39.9	35.6
48.0	36.0	34.4	33.6	34.6	38.8	46.1	53.8	57.3	55.2	49.2	42.8	38.3
60.0	37.7	35.7	34.7	35.3	38.8	44.8	51.0	54.2	53.7	49.8	44.4	40.2
90.0	41.2	39.3	37.9	37.4	38.7	42.0	46.6	50.8	51.9	50.0	46.4	43.4
120.0	41.8	39.8	38.5	37.9	38.7	41.7	46.1	50.0	51.4	50.1	46.9	43.9

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
12.0	43.2	17.6	C.79	3.2
24.0	43.5	15.4	0.92	2.4
36.0	42.8	13.1	1.04	2.2
48.0	43.4	11.5	1.21	2.1
60.0	43.4	9.7	1.33	1.4
90.0	43.8	6.9	1.66	1.1
120.0	43.9	6.5	1.74	1.0

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
12.0	26.8	26.4	30.4	38.3	47.5	56.0	61.1	61.6	57.3	49.5	40.0	31.9
24.0	30.1	28.6	30.9	36.9	44.7	52.4	57.7	59.4	56.9	50.9	42.9	35.5
36.0	33.1	30.8	31.8	36.2	42.5	49.5	54.7	57.2	56.0	51.7	45.1	38.4
48.0	35.7	32.9	33.0	36.0	41.0	47.0	52.1	55.0	54.9	51.9	46.7	40.9
60.0	38.0	35.0	34.3	36.1	40.1	45.2	49.8	53.0	53.7	51.8	47.7	42.8
90.0	42.2	39.2	37.6	37.5	39.2	42.3	45.7	48.7	50.5	50.4	48.7	45.7
120.0	44.5	42.2	40.4	39.5	39.8	41.3	43.4	45.8	47.7	48.5	48.2	46.7

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =44.0,B0=21.0,PC=0.68 ,D=.015

EARTH TEMPERATURE STATION BOZEMAN, MONTANA

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 44.0 ,BO= 21.0 AND PO= 0.63

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
24.0	28.4	27.7	31.1	38.2	46.6	54.6	59.5	60.3	56.6	49.6	41.0	33.3
48.0	33.1	31.0	32.2	36.7	43.0	49.7	54.7	57.0	55.6	51.2	44.7	38.2
72.0	37.0	34.2	34.0	36.4	40.8	46.2	50.8	53.8	54.0	51.5	47.0	41.7
96.0	40.0	37.1	36.0	36.9	39.7	43.8	47.8	50.9	52.1	51.1	48.1	44.1
120.0	42.3	39.5	37.9	37.9	39.5	42.3	45.6	48.5	50.1	50.1	48.4	45.6
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	34.3	32.4	33.5	37.5	43.1	49.1	53.5	55.5	54.3	50.4	44.6	38.8

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	58.4	59.9	60.3	60.6	61.0
48.0	53.3	56.2	57.0	57.6	58.4
72.0	49.0	52.7	53.8	54.6	55.8
96.0	46.1	49.7	50.9	51.8	53.3
120.0	44.3	47.3	48.5	49.5	51.0
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	52.1	54.7	55.5	56.2	57.1

EARTH TEMPERATURE STATION — HUNTLEY, MONTANA
TYPE OF SOIL — CLAY
TYPE OF EARTH SURFACE — SOD
DATA PROCESSED BY
DATA SOURCE — CLIMATOLOGICAL DATA

PERIOD OF OBSERVATION — 1961-1962

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
2.0	27.8	32.0	37.8	48.6	59.8	71.4	75.1	71.9	58.3	48.6	37.5	30.3
4.0	26.9	30.2	36.0	47.8	58.5	70.1	74.1	71.1	58.7	48.6	37.3	30.5
8.0	28.1	30.2	34.3	44.6	54.8	66.1	70.7	69.3	57.9	48.1	38.2	34.3
20.0	33.5	33.3	37.3	44.6	53.7	63.7	71.6	70.5	61.8	52.5	43.0	36.4
40.0	37.4	36.9	38.3	42.1	48.9	57.2	65.9	63.6	60.7	56.0	48.3	42.3
60.0	39.9	38.4	38.9	41.0	47.2	53.5	60.4	64.6	63.7	59.7	55.7	48.1

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
2.0	49.9	23.4	0.50	3.1
4.0	49.2	23.4	0.53	3.0
8.0	48.1	21.0	0.62	3.0
20.0	50.1	19.4	0.73	2.2
40.0	49.9	14.6	0.99	2.1
60.0	51.1	13.3	1.32	4.1

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
2.0	25.6	29.3	38.0	50.5	62.5	71.4	74.4	70.9	61.5	49.3	37.0	28.5
4.0	26.1	29.4	37.8	49.9	61.7	70.7	73.9	70.7	61.7	49.9	37.7	29.2
8.0	27.1	29.8	37.5	48.9	60.3	69.3	72.8	70.3	62.0	50.9	39.1	30.6
20.0	30.3	31.3	36.9	46.4	56.6	65.3	69.6	68.8	62.7	53.4	42.9	34.6
40.0	35.2	34.2	37.1	43.7	51.8	59.6	64.7	65.9	62.6	56.2	47.8	40.3
60.0	39.5	37.3	38.3	42.5	48.6	55.2	60.3	62.7	61.6	57.4	51.1	44.7

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =50.0, B0=25.0, PC=0.47 , D=.020

EARTH TEMPERATURE STATION HUNTLEY, MONTANA

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 50.0 ,B0= 25.0 AND P0= 0.47

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	30.6	31.5	36.9	46.1	56.2	64.8	69.3	68.6	62.8	53.7	43.3	35.1
48.0	35.8	34.6	37.2	43.4	51.2	58.9	64.0	65.4	62.5	56.4	48.4	41.0
72.0	40.3	37.9	38.6	42.4	48.1	54.4	59.5	62.1	61.3	57.5	51.6	45.5
96.0	44.0	41.1	40.5	42.4	46.3	51.3	55.8	58.9	59.5	57.6	53.5	48.6
120.0	46.8	43.8	42.5	43.1	45.5	49.2	53.0	56.1	57.5	56.9	54.3	50.7
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	37.4	36.3	38.6	44.2	51.1	57.9	62.5	63.7	61.2	55.7	48.6	42.0

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	66.8	68.3	68.6	68.9	69.2
48.0	61.5	64.6	65.4	66.0	66.8
72.0	56.8	60.9	62.1	62.9	64.2
96.0	53.2	57.5	58.9	59.9	61.5
120.0	50.9	54.7	56.1	57.3	59.0
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	59.8	62.8	63.7	64.4	65.4

EARTH TEMPERATURE STATION	LINCOLN, NEBRASKA
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	BARE
DATA PROCESSED BY	E.M.FITTON
DATA SOURCE	REFERENCE(4)
PERIOD OF OBSERVATION	1900-1904

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR											
	J	F	M	A	M	J	J	A	S	O	N	D
1.0	30.0	28.2	42.4	58.6	74.5	82.3	90.8	85.6	72.0	60.0	43.5	31.0
3.0	30.0	28.7	41.1	59.3	72.1	81.2	88.6	85.3	72.9	61.4	44.3	31.6
6.0	29.6	28.0	37.9	54.5	68.7	77.5	83.6	82.0	71.0	60.2	44.1	31.9
9.0	30.0	28.4	35.7	50.8	64.4	73.0	79.4	77.9	70.5	59.0	44.3	33.4
12.0	31.4	29.3	35.0	48.2	60.8	69.5	75.8	75.0	66.6	58.4	45.1	34.8
24.0	35.1	32.9	34.7	44.8	56.5	64.2	70.8	71.6	66.9	59.7	49.5	39.5
36.0	38.1	35.3	35.7	43.0	53.2	61.1	67.5	69.4	66.7	60.7	52.1	43.2

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
1.0	58.4	30.9	0.53	2.0
3.0	58.2	30.1	0.57	1.9
6.0	55.9	28.3	0.62	1.5
9.0	54.0	26.0	0.68	1.2
12.0	52.6	23.5	0.73	1.2
24.0	52.3	19.7	0.89	1.0
36.0	52.3	17.3	1.03	0.8

EARTH TEMPERATURE STATION LINCOLN, NEBRASKA

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 54.0 ,B0= 28.0 AND PO= 0.52

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	32.5	32.9	38.5	48.6	59.9	69.8	75.3	75.2	69.1	59.2	47.6	38.0
48.0	38.5	36.7	39.2	45.9	54.5	63.3	69.3	71.3	68.5	62.0	53.0	44.6
72.0	43.6	40.6	41.0	44.9	51.2	58.3	64.2	67.4	66.9	63.0	56.5	49.5
96.0	47.7	44.2	43.3	45.2	49.3	54.9	60.1	63.7	64.7	62.8	58.4	53.0
120.0	50.8	47.4	45.7	46.1	48.6	52.7	57.0	60.6	62.4	61.9	59.2	55.2
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	40.2	38.6	40.8	46.8	54.4	62.2	67.6	69.4	66.9	61.1	53.2	45.7

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	73.0	74.7	75.2	75.5	75.9
48.0	66.8	70.4	71.3	72.0	73.0
72.0	61.3	66.0	67.4	68.4	69.8
96.0	57.4	62.2	63.7	65.0	66.8
120.0	54.8	59.0	60.6	61.9	63.9
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	65.0	68.4	69.4	70.2	71.3

EARTH TEMPERATURE STATION	LINCOLN, NEBRASKA
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	UNKNOWN
DATA PROCESSED BY	C.M.FITTON
DATA SOURCE	REFERENCE(4)
PERIOD OF OBSERVATION	1854-1904

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
1.0	28.2	29.0	40.1	58.7	70.9	79.2	86.9	85.1	73.7	58.1	40.6	31.2
3.0	38.5	27.8	38.8	57.6	69.7	78.1	85.1	84.0	73.5	59.4	42.7	31.4
6.0	29.0	28.1	37.4	53.6	66.7	76.1	82.1	80.9	72.0	58.3	42.6	31.7
9.0	29.8	28.0	36.0	50.8	64.2	73.7	79.7	78.9	71.0	58.5	38.9	28.8
12.0	30.2	29.9	35.6	49.1	61.2	69.7	75.8	75.6	69.2	57.9	44.5	34.6
24.0	35.1	33.1	35.3	45.4	56.9	64.6	70.5	72.0	68.2	60.0	49.2	39.5
36.0	38.1	35.1	36.0	43.6	53.8	61.5	67.7	69.8	67.9	61.3	51.9	43.0

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
1.0	56.9	30.3	0.55	2.0
3.0	57.3	27.8	0.60	3.9
6.0	55.0	27.9	0.62	1.2
9.0	53.3	27.3	0.63	2.2
12.0	52.9	23.9	0.72	0.9
24.0	52.6	19.9	0.89	0.9
36.0	52.6	17.7	1.03	0.7

EARTH TEMPERATURE STATION LINCOLN, NEBRASKA

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 53.0 ,BO= 28.0 AND PO= 0.52

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	31.5	31.9	37.5	47.6	58.9	68.8	74.3	74.2	68.1	58.2	46.6	37.0
48.0	37.5	35.7	38.2	44.9	53.5	62.3	68.3	70.3	67.5	61.0	52.0	43.6
72.0	42.6	39.6	40.0	43.9	50.2	57.3	63.2	66.4	65.9	62.0	55.5	48.5
96.0	46.7	43.2	42.3	44.2	48.3	53.9	59.1	62.7	63.7	61.8	57.4	52.0
120.0	49.8	46.4	44.7	45.1	47.6	51.7	56.0	59.6	61.4	60.9	58.2	54.2
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	39.2	37.6	39.8	45.8	53.4	61.2	66.6	68.4	65.9	60.1	52.2	44.7

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	72.0	73.7	74.2	74.5	74.9
48.0	65.8	69.4	70.3	71.0	72.0
72.0	60.3	65.0	66.4	67.4	68.8
96.0	56.4	61.2	62.7	64.0	65.8
120.0	53.8	58.0	59.6	60.9	62.9
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	64.0	67.4	68.4	69.2	70.3

EARTH TEMPERATURE STATION	NORFOLK, NEBRASKA
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	UNKNOWN
DATA PROCESSED BY	JEN-HU-CHANG
DATA SOURCE	REFERENCE(5)
PERIOD OF OBSERVATION	1950-1952

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
3.9	29.9	33.6	36.2	63.0	71.6	78.0	71.9	65.0	50.6	37.7	34.0	
7.9	31.0	36.4	35.8	63.2	72.6	79.0	73.0	67.7	56.8	40.6	33.7	
11.8	29.7	35.4	33.2	62.2	71.5	76.7	73.8	68.1	57.6	41.7	33.8	
19.7	30.1	34.9	32.0	60.8	70.0	75.0	72.9	68.0	56.8	43.4	34.4	
39.4	33.7	34.3	33.7	57.8	66.8	72.5	71.6	67.7	59.0	47.6	38.2	

RESLLTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
3.9	52.4	23.5	0.57	2.3
7.9	53.5	23.5	0.60	2.5
11.8	52.9	23.7	0.67	2.5
19.7	52.3	23.0	0.70	2.5
39.4	52.5	20.6	0.83	1.5

EARTH TEMPERATURE STATION NORFOLK, NEBRASKA

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 53.0 ,BO= 24.0 AND PO= 0.54

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	34.7	34.8	39.4	48.0	57.7	66.3	71.2	71.2	66.2	57.8	47.9	39.6
48.0	39.9	38.1	40.2	45.8	53.1	60.7	66.0	67.9	65.6	60.1	52.5	45.2
72.0	44.2	41.6	41.8	45.1	50.3	56.5	61.6	64.4	64.1	60.9	55.4	49.4
96.0	47.8	44.7	43.8	45.3	48.8	53.6	58.0	61.3	62.2	60.6	57.0	52.3
120.0	50.4	47.4	45.9	46.2	48.3	51.7	55.4	58.6	60.1	59.8	57.6	54.2
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	41.3	39.8	41.6	46.6	53.1	59.8	64.5	66.2	64.2	59.3	52.5	46.1

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	69.3	70.9	71.2	71.5	71.9
48.0	63.9	67.0	67.9	68.5	69.3
72.0	59.2	63.3	64.4	65.3	66.6
96.0	55.8	59.9	61.3	62.3	63.9
120.0	53.6	57.2	58.6	59.7	61.4
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	62.4	65.3	66.2	66.9	67.9

EARTH TEMPERATURE STATION	NEW BRUNSWICK, N.J.
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	BLUE GRASS SOD
DATA PROCESSED BY	JEN-HU-CHANG
DATA SOURCE	REFERENCE(5)
PERIOD OF OBSERVATION	1953-1955

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
1.0	32.9	34.9	39.3	50.4	62.0	69.6	78.7	75.2	67.6	59.7	45.9	35.9
3.0	33.6	35.0	39.7	49.9	57.6	67.9	73.9	72.0	66.7	60.2	46.7	38.2
10.0	35.2	35.3	39.9	48.9	56.5	65.6	71.7	71.3	66.8	60.4	48.2	39.8
24.0	37.8	36.4	40.1	47.0	54.4	62.6	68.3	69.8	66.4	61.4	50.8	42.8

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
1.0	54.5	22.3	0.69	1.4
3.0	53.6	20.0	0.75	1.1
10.0	53.4	18.7	0.81	0.8
24.0	53.2	16.7	0.94	0.6

EARTH TEMPERATURE STATION NEW BRUNSWICK,N.J.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 53.0 ,BO= 21.0 AND PO= 0.69

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	37.8	36.6	39.5	46.3	54.6	62.8	68.1	69.4	66.2	59.6	50.9	43.1
48.0	42.5	40.1	40.9	45.1	51.2	58.0	63.3	65.9	64.9	60.9	54.5	47.9
72.0	46.4	43.4	42.9	45.0	49.2	54.6	59.4	62.6	63.1	60.9	56.6	51.3
96.0	49.5	46.3	45.0	45.7	48.3	52.3	56.4	59.6	61.0	60.3	57.5	53.6
120.0	51.6	48.8	47.0	46.8	48.2	51.0	54.2	57.2	59.0	59.2	57.7	55.0
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	43.7	41.5	42.3	45.9	51.4	57.4	62.1	64.5	63.6	60.0	54.3	48.5

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	67.4	69.0	69.4	69.7	70.1
48.0	62.0	65.1	65.9	66.5	67.4
72.0	57.8	61.5	62.6	63.4	64.6
96.0	54.8	58.4	59.6	60.6	62.0
120.0	53.1	56.0	57.2	58.2	59.7
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	60.9	63.6	64.5	65.1	66.1

EARTH TEMPERATURE STATION	ITHACA,NEW YORK
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	GRASS SOD
DATA PROCESSED BY	JEN-HU-CHANG
DATA SOURCE	REFERENCE(5)
PERIOD OF OBSERVATION	1941-1946

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
3.0	32.4	31.4	35.7	43.8	54.6	62.9	67.6	66.3	63.0	51.3	41.1	33.8
6.0	32.8	31.8	35.5	43.3	53.6	62.2	67.1	66.2	63.3	52.0	42.0	34.4
12.0	33.9	32.7	35.2	42.5	52.1	60.6	65.8	65.6	63.1	53.4	43.5	36.1
24.0	36.5	34.6	35.7	41.6	49.8	56.4	63.7	64.5	62.8	55.3	46.6	39.1
48.0	40.0	37.7	37.3	40.6	45.9	52.8	58.3	61.0	61.1	56.9	50.6	43.9
96.0	45.7	43.0	41.1	41.6	53.8	47.5	51.4	54.5	56.7	56.1	53.2	49.3

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
3.0	48.8	18.9	C.71	1.3
6.0	48.8	18.5	0.75	1.2
12.0	48.8	17.5	C.83	1.1
24.0	49.0	15.4	0.97	1.1
48.0	48.9	12.2	1.23	0.6
96.0	49.5	6.8	1.51	2.9

EARTH TEMPERATURE STATION ITHACA,NEW YORK

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 49.0 ,BO= 19.0 AND PO= 0.69

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	35.2	34.2	36.8	42.9	50.5	57.8	62.6	63.9	60.9	54.9	47.1	40.1
48.0	39.5	37.3	38.1	41.8	47.4	53.5	58.3	60.7	59.8	56.1	50.3	44.4
72.0	43.1	40.3	39.8	41.8	45.6	50.4	54.8	57.6	58.1	56.2	52.2	47.5
96.0	45.8	43.0	41.7	42.4	44.8	48.4	52.0	55.0	56.3	55.6	53.1	49.6
120.0	47.8	45.2	43.6	43.4	44.7	47.2	50.1	52.8	54.5	54.6	53.2	50.8
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	40.6	38.6	39.3	42.6	47.5	53.0	57.3	59.4	58.6	55.3	50.2	44.9

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	62.0	63.5	63.9	64.1	64.5
48.0	57.2	59.9	60.7	61.2	62.0
72.0	53.3	56.7	57.6	58.4	59.5
96.0	50.7	53.9	55.0	55.9	57.2
120.0	49.1	51.7	52.8	53.7	55.1
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	56.2	58.6	59.4	60.0	60.8

EARTH TEMPERATURE STATION	ITHACA,NEW YORK
TYPE OF SOIL	LOAM
TYPE OF EARTH SURFACE	GRASS-SOD
DATA PROCESSED BY	
DATA SOURCE	US WEATHER R.C.
PERIOD OF OBSERVATION	1943-1947

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
0.	31.6	31.2	36.0	43.6	54.2	65.0	69.0	66.4	57.8	49.8	39.2	33.4
3.0	32.2	31.8	35.0	42.8	52.8	63.8	68.6	66.0	58.4	50.6	40.4	34.4
6.0	32.8	32.2	35.2	41.4	52.4	63.4	67.4	66.0	58.8	51.2	41.2	35.2
12.0	33.8	33.2	35.2	41.6	51.2	61.4	66.2	64.0	59.0	51.0	44.0	37.2
24.0	36.6	35.2	35.6	41.2	48.8	59.0	64.2	64.2	60.2	54.4	47.6	40.6
48.0	40.2	38.4	37.4	40.6	45.2	52.0	59.2	61.0	59.8	55.8	51.0	45.4
96.0	46.0	43.2	41.4	41.6	43.8	48.2	52.6	55.4	56.8	55.8	52.7	49.2

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
0.	48.2	19.1	0.64	3.1
3.0	48.2	18.5	0.69	3.1
6.0	48.2	18.0	0.73	3.0
12.0	48.3	16.5	0.80	2.6
24.0	49.0	15.0	0.96	2.7
48.0	48.9	11.8	1.25	2.6
96.0	49.0	7.7	1.65	1.2

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
0.	30.1	31.6	37.3	46.6	56.2	64.1	67.8	66.5	60.3	51.3	41.4	33.8
3.0	30.8	31.9	37.2	46.1	55.4	63.3	67.2	66.2	60.4	51.8	42.1	34.6
6.0	31.4	32.2	37.2	45.6	54.7	62.5	66.5	65.8	60.5	52.2	42.8	35.4
12.0	32.7	32.9	37.1	44.8	53.4	61.0	65.2	65.1	60.6	53.1	44.2	36.9
24.0	35.1	34.4	37.3	43.5	51.1	58.2	62.7	63.6	60.5	54.3	46.6	39.7
48.0	39.5	37.5	38.4	42.2	47.7	53.7	58.3	60.5	59.5	55.7	50.0	44.2
96.0	45.9	43.2	42.0	42.7	45.0	48.5	52.0	54.8	56.0	55.3	52.9	49.5

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =49.0,B0=19.0,PC=0.64 ,D=.023

EARTH TEMPERATURE STATION ITHACA,NEW YORK

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 49.0 ,BO= 19.0 AND PO= 0.64

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	34.9	34.3	37.3	43.6	51.2	58.4	62.9	63.8	60.5	54.3	46.4	39.5
48.0	39.2	37.3	38.3	42.3	47.9	54.0	58.6	60.7	59.6	55.6	49.8	43.9
72.0	42.7	40.2	39.7	42.1	46.0	50.9	55.1	57.8	58.0	55.9	51.8	47.0
96.0	45.5	42.8	41.7	42.6	45.1	48.7	52.4	55.2	56.3	55.4	52.8	49.2
120.0	47.5	45.0	43.5	43.4	44.8	47.4	50.4	53.0	54.5	54.6	53.0	50.5
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	40.3	38.6	39.5	43.0	48.0	53.5	57.6	59.4	58.4	54.9	49.7	44.4

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	62.0	63.4	63.8	64.0	64.4
48.0	57.3	60.0	60.7	61.3	62.0
72.0	53.5	56.8	57.8	58.5	59.6
96.0	50.8	54.1	55.2	56.1	57.3
120.0	49.2	51.9	53.0	53.9	55.3
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	56.3	58.7	59.4	60.0	60.8

EARTH TEMPERATURE STATION	RALEIGH,N.C.
TYPE OF SOIL	SANDY LOAM
TYPE OF EARTH SURFACE	BARE
DATA PROCESSED BY	
DATA SOURCE	CLIMATOLOGICAL DATA
PERIOD OF OBSERVATION	1960-1962

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR											
	J	F	M	A	M	J	J	A	S	O	N	D
4.0	41.6	44.7	48.6	62.1	72.6	77.6	79.7	80.4	74.7	66.6	54.8	43.3
8.0	41.4	44.4	48.4	60.8	71.9	76.9	79.3	79.4	74.3	66.3	55.1	43.8

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
4.0	62.4	20.2	C.62	3.1
8.0	62.0	19.8	0.64	2.9

EARTH TEMPERATURE STATION RALEIGH,N.C.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 62.0 ,BO= 19.0 AND PO= 0.60

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
	MONTH OF YEAR											
24.0	47.7	47.4	50.7	57.2	64.8	71.9	76.1	76.6	73.1	66.7	58.8	52.0
48.0	51.9	50.2	51.5	55.7	61.4	67.5	71.9	73.8	72.3	68.2	62.3	56.4
72.0	55.4	53.1	53.0	55.3	59.4	64.2	68.4	70.9	71.0	68.6	64.4	59.7
96.0	58.2	55.6	54.7	55.7	58.3	62.0	65.6	68.3	69.3	68.3	65.5	61.9
120.0	60.3	57.8	56.4	56.5	58.0	60.7	63.6	66.2	67.6	67.5	65.9	63.3
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	53.1	51.5	52.7	56.4	61.5	66.9	70.8	72.5	71.2	67.5	62.3	57.1

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES				
	C 010	0.020	0.025	0.030	0.040
24.0	75.0	76.3	76.6	76.9	77.2
48.0	70.5	73.1	73.8	74.3	75.0
72.0	66.7	70.0	70.9	71.6	72.7
96.0	64.0	67.3	68.3	69.2	70.5
120.0	62.3	65.1	66.2	67.1	68.4
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	69.3	71.7	72.5	73.0	73.8

EARTH TEMPERATURE STATION	COLUMBUS,OHIO
TYPE OF SOIL	SILT LOAM
TYPE OF EARTH SURFACE	GRASS
DATA PROCESSED BY	
DATA SOURCE	CLIMATOLOGICAL DATA
PERIOD OF OBSERVATION	1960-1962

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR											
	J	F	M	A	M	J	J	A	S	O	N	D
4.0	31.0	32.2	37.2	48.2	58.8	66.4	70.9	69.9	67.1	55.6	43.9	32.8
8.0	34.5	34.6	38.9	48.1	59.7	69.6	72.8	72.8	69.6	56.4	46.8	34.8
20.0	37.5	36.0	39.4	46.6	56.7	65.5	69.4	70.0	67.6	59.7	49.3	40.7
39.0	41.6	39.5	41.2	46.5	54.7	61.9	66.7	68.1	67.2	60.8	53.2	45.2

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
4.0	51.3	21.0	0.70	2.8
8.0	53.3	21.0	0.72	2.6
20.0	53.3	17.8	0.86	1.8
39.0	54.0	14.7	1.00	1.6

EARTH TEMPERATURE STATION COLUMBUS,OHIO

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 53.0 ,BO= 22.0 AND PO= 0.65

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	36.8	35.9	39.3	46.6	55.4	63.8	69.1	70.1	66.4	59.2	50.2	42.1
48.0	41.7	39.4	40.6	45.1	51.6	58.7	64.1	66.6	65.3	60.8	54.0	47.2
72.0	45.8	42.8	42.5	44.9	49.4	55.1	60.0	63.2	63.5	61.0	56.3	50.8
96.0	49.0	45.9	44.6	45.5	48.4	52.6	56.8	60.1	61.4	60.5	57.4	53.3
120.0	51.3	48.4	46.7	46.5	48.1	51.1	54.5	57.6	59.4	59.4	57.7	54.8
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	43.0	40.9	41.9	46.0	51.8	58.1	62.9	65.1	63.9	59.9	53.9	47.8

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	69.1	69.7	70.1	70.4	70.8
48.0	62.6	65.7	66.6	67.2	68.1
72.0	58.2	62.0	63.2	64.0	65.3
96.0	55.1	58.9	60.1	61.1	62.6
120.0	53.2	56.4	57.6	58.6	60.3
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	61.4	64.2	65.1	65.7	66.7

EARTH TEMPERATURE STATION	COSHOCTON,OHIO
TYPE OF SOIL	SILT LOAM
TYPE OF EARTH SURFACE	MEADOW
DATA PROCESSED BY	JEN-HU-CHANG
DATA SOURCE	REFERENCE(5)
PERIOD OF OBSERVATION	1942-1955

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
0.5	31.6	32.0	38.4	48.1	59.2	71.2	75.5	73.9	69.9	55.5	41.6	33.0
3.0	32.6	32.5	38.0	46.6	57.9	69.2	72.8	71.4	65.7	54.8	42.4	34.3
6.0	33.0	32.9	38.5	47.6	58.2	69.4	72.9	72.0	67.1	56.9	44.8	33.0
12.0	34.6	33.9	38.0	46.4	55.6	65.8	70.5	70.2	65.9	57.3	46.7	37.7
24.0	36.6	35.0	38.8	46.2	55.0	63.4	68.8	68.6	65.5	57.6	48.3	38.8

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
0.5	52.6	23.2	0.67	1.7
3.0	51.6	21.2	0.68	1.2
6.0	53.1	20.2	0.76	1.9
12.0	52.0	19.1	0.80	0.6
24.0	52.0	17.4	0.84	0.7

STA-45

EARTH TEMPERATURE STATION COSHOCTON,OHIO

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 52.0 ,BO= 22.C AND PO= 0.67

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	35.9	34.9	38.1	45.3	54.1	62.5	67.9	69.2	65.6	58.6	49.5	41.4
48.0	40.9	38.4	39.5	43.9	50.4	57.5	62.9	65.5	64.4	60.0	53.3	46.4
72.0	45.0	41.9	41.4	43.8	48.2	53.9	58.8	62.1	62.5	60.2	55.5	50.1
96.0	48.1	44.9	43.6	44.4	47.2	51.4	55.7	59.0	60.4	59.5	56.6	52.5
120.0	50.4	47.5	45.7	45.5	47.1	50.0	53.4	56.5	58.4	58.5	56.8	53.9
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	42.1	39.9	40.8	44.8	50.5	56.9	61.7	64.1	63.0	59.1	53.2	47.0

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	67.1	68.7	69.2	69.5	69.9
48.0	61.6	64.7	65.5	66.2	67.1
72.0	57.1	60.9	62.1	63.0	64.2
96.0	54.0	57.8	59.0	60.0	61.6
120.0	52.2	55.3	56.5	57.5	59.2
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	60.4	63.2	64.1	64.7	65.7

EARTH TEMPERATURE STATION	BARNSDALL,OKLA.
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	UNKNOWN
DATA PROCESSED BY	JEN-HU-CHANG
DATA SOURCE	REFERENCE(5)
PERIOD OF OBSERVATION	1950-1952

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
3.9	41.1	43.0	44.8	54.3	66.3	76.0	80.8	81.2	73.2	65.0	47.9	41.6
7.9	42.6	44.4	46.4	55.7	67.2	77.0	81.3	82.6	74.6	66.4	50.2	43.3
11.8	46.1	47.4	49.6	58.7	67.8	75.6	79.2	81.7	75.0	68.6	54.8	46.4
19.7	50.0	50.2	52.6	59.6	68.6	76.3	80.5	81.6	76.8	70.9	58.0	50.1
39.4	52.8	52.2	53.9	58.3	66.0	73.2	75.1	81.4	78.2	74.6	63.6	55.4

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
3.9	60.0	21.3	0.68	2.3
7.9	61.1	20.9	0.70	2.1
11.8	62.7	18.3	0.73	1.7
19.7	64.7	16.8	0.77	1.6
39.4	65.5	14.4	1.01	1.7

EARTH TEMPERATURE STATION BARNSDALL,OKLA.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 65.0 ,BO= 21.0 AND PO= 0.65

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	49.5	48.7	51.9	58.9	67.3	75.3	80.3	81.3	77.8	71.0	62.3	54.6
48.0	54.2	52.0	53.1	57.5	63.7	70.5	75.6	78.0	76.7	72.4	66.0	59.4
72.0	58.1	55.3	54.9	57.3	61.6	67.0	71.7	74.7	75.0	72.[illegible]	68.2	62.9
96.0	61.2	58.2	57.0	57.8	60.6	64.6	68.7	71.8	73.1	72.1	69.2	65.3
120.0	63.4	60.6	58.9	58.8	60.4	63.2	66.5	69.4	71.1	71.2	69.5	66.7
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	55.4	53.5	54.4	58.3	63.8	69.9	74.4	76.5	75.4	71.6	65.9	60.1

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	79.4	80.9	81.3	81.6	82.0
48.0	74.2	77.2	78.0	78.5	79.4
72.0	70.0	73.6	74.7	75.5	76.7
96.0	67.0	70.6	71.8	72.8	74.2
120.0	65.2	68.2	69.4	70.4	71.9
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	73.0	75.7	76.5	77.2	78.1

EARTH TEMPERATURE STATION	HOMINY, OKLA.
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	UNKNOWN
DATA PROCESSED BY	JEN-HU-CHANG
DATA SOURCE	REFERENCE(5)
PERIOD OF OBSERVATION	1950-1952

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
3.9	46.2	46.4	50.2	57.5	68.1	77.8	84.7	84.8	79.2	69.4	55.7	49.0
7.9	44.4	44.7	48.7	55.8	67.5	77.9	85.1	85.4	79.4	68.6	54.3	46.8
11.8	45.8	46.0	49.8	56.7	67.7	76.8	83.5	83.8	78.2	68.9	55.3	48.7
19.7	48.9	46.6	50.0	56.6	67.8	76.7	83.2	83.0	78.0	68.4	59.2	48.2
39.4	48.4	45.7	49.1	55.9	66.0	73.8	80.1	82.1	77.1	68.2	61.6	47.3

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
3.9	64.2	20.2	0.78	1.6
7.9	63.3	21.5	0.77	1.8
11.8	63.5	19.9	0.78	1.5
19.7	64.0	18.9	0.80	1.7
39.4	63.0	18.2	0.87	1.8

EARTH TEMPERATURE STATION HOPINY,OKLA.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 63.0 ,BO= 21.0 AND PO= 0.73

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	48.0	46.5	49.2	55.7	64.0	72.2	77.8	79.5	76.6	70.2	61.6	53.7
48.0	52.8	50.2	50.7	54.7	60.7	67.5	72.9	75.8	75.1	71.3	65.0	58.4
72.0	56.8	53.6	52.8	54.8	58.8	64.2	69.0	72.4	73.2	71.2	66.9	61.8
96.0	59.7	56.5	55.0	55.6	58.1	62.0	66.1	69.4	71.0	70.4	67.8	63.9
120.0	61.9	58.9	57.1	56.7	58.0	60.7	64.0	67.0	68.9	69.3	67.9	65.2
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	54.0	51.6	52.1	55.6	60.9	67.0	71.8	74.4	73.8	70.4	64.8	58.9

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	77.3	79.1	79.5	79.8	80.2
48.0	71.9	75.0	75.8	76.5	77.3
72.0	67.6	71.3	72.4	73.3	74.5
96.0	64.7	68.2	69.4	70.4	71.9
120.0	63.0	65.8	67.0	68.0	69.6
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	70.8	73.6	74.4	75.1	76.0

EARTH TEMPERATURE STATION	LAKE MEPHER,OKLA.
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	UNKNOWN
DATA PROCESSED BY	JEN-HU-CHANG
DATA SOURCE	REFERENCE(S)
PERIOD OF OBSERVATION	1950-1952

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
3.9	39.3	41.7	49.1	58.3	72.0	81.0	81.9	83.6	75.6	70.7	51.8	41.9
7.9	41.3	41.5	49.0	57.3	69.0	80.2	86.6	86.5	78.6	71.8	53.7	44.9
11.8	44.7	43.5	49.8	59.4	69.8	78.8	81.8	84.5	78.1	74.6	58.6	47.9
39.4	49.1	46.7	50.5	56.5	65.8	73.2	77.8	81.0	77.4	74.3	64.6	53.3

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
3.9	62.4	22.9	0.66	2.4
7.9	63.5	23.5	0.75	1.7
11.8	64.4	20.7	0.80	2.0
39.4	64.3	16.9	1.00	1.3

EARTH TEMPERATURE STATION LAKE HEFNER,OKLA.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 64.0 ,BO= 23.0 AND PO= 0.63

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	46.9	46.2	49.9	57.7	66.9	75.6	80.9	81.8	77.8	70.2	60.7	52.3
48.0	52.0	49.8	51.1	56.0	62.9	70.2	75.7	78.2	76.7	71.9	64.8	57.7
72.0	56.3	53.3	53.0	55.7	60.5	66.4	71.5	74.7	74.9	72.3	67.3	61.5
96.0	59.6	56.4	55.2	56.2	59.3	63.8	68.2	71.5	72.8	71.7	68.5	64.2
120.0	62.1	59.1	57.3	57.3	59.0	62.2	65.7	68.9	70.7	70.7	68.9	65.8
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	53.4	51.3	52.5	56.9	63.0	69.5	74.4	76.6	75.3	71.0	64.7	58.4

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	79.7	81.4	81.8	82.1	82.6
48.0	74.1	77.4	78.2	78.8	79.7
72.0	69.5	73.5	74.7	75.6	76.9
96.0	66.3	70.2	71.5	72.6	74.1
120.0	64.3	67.6	68.9	70.0	71.7
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	72.8	75.8	76.6	77.3	78.3

EARTH TEMPERATURE STATION	PAWHUSKA,OKLA
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	UNKNOWN
DATA PROCESSED BY	JEN-HU-CHANG
DATA SOURCE	REFERENCE(5)
PERIOD OF OBSERVATION	1950-1952

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
3.9	41.0	41.2	45.1	56.1	69.1	80.6	81.7	82.6	74.4	65.6	48.4	41.4
7.9	39.8	40.8	43.8	53.9	65.8	76.6	79.8	80.8	73.1	64.4	48.2	41.2
11.8	44.6	44.6	48.0	56.4	65.5	74.4	78.4	80.8	74.1	67.6	55.2	46.8
19.7	46.6	46.3	49.2	54.1	64.5	72.1	77.0	78.7	74.8	69.0	58.4	49.6
39.4	50.2	49.0	50.5	54.6	63.2	67.4	73.6	76.5	74.8	70.2	62.2	54.1

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
3.9	60.7	22.8	0.65	2.1
7.9	59.1	21.8	0.69	1.8
11.8	61.5	18.5	0.78	1.1
19.7	61.8	16.8	0.89	1.0
39.4	62.2	13.9	1.06	1.0

EARTH TEMPERATURE STATION PAWHUSKA,OKLA

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 62.0 ,BO= 22.0 AND PO= 0.61

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	45.5	45.0	48.8	56.3	65.1	73.3	78.3	79.0	75.0	67.6	58.5	50.6
48.0	50.4	48.4	49.8	54.6	61.2	68.2	73.4	75.6	74.0	69.3	62.5	55.7
72.0	54.5	51.7	51.5	54.2	58.8	64.5	69.3	72.3	72.4	69.8	64.9	59.4
96.0	57.7	54.7	53.6	54.7	57.7	61.9	66.1	69.3	70.4	69.3	66.1	62.0
120.0	60.1	57.2	55.6	55.6	57.3	60.4	63.8	66.8	68.5	68.4	66.5	63.6
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	51.7	49.9	51.1	55.4	61.3	67.5	72.1	74.1	72.7	68.5	62.4	56.4

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	77.0	78.6	79.0	79.3	79.7
48.0	71.8	74.8	75.6	76.2	77.0
72.0	67.4	71.2	72.3	73.1	74.3
96.0	64.3	68.0	69.3	70.3	71.8
120.0	62.4	65.5	66.8	67.8	69.4
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	70.5	73.3	74.2	74.8	75.7

EARTH TEMPERATURE STATION	OTTAWA, ONTARIO
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	UNKNOWN
DATA PROCESSED BY	E.F.PENROD
DATA SOURCE	REFERENCE(9)
PERIOD OF OBSERVATION	1950

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
12.0	32.6	30.6	30.8	35.0	49.7	58.2	66.0	63.6	56.9	48.2	40.2	34.8
24.0	34.9	33.6	33.0	34.6	45.8	57.2	64.1	63.4	58.8	51.6	43.5	38.1
48.0	40.2	38.3	36.7	36.6	41.9	50.1	56.3	58.8	57.9	54.1	48.4	42.8
96.0	46.0	44.5	43.1	41.8	41.6	43.9	47.5	50.5	52.3	52.7	51.4	48.4

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P,	STANDARD DEVIATION
12.0	45.6	17.5	0.83	2.9
24.0	46.6	15.9	0.98	2.7
48.0	46.9	11.3	1.31	1.6
96.0	47.0	5.4	2.01	0.7

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
12.0	30.0	29.9	33.9	41.8	50.8	59.1	63.9	64.2	59.8	52.1	42.7	34.8
24.0	33.6	32.1	34.4	40.2	47.7	55.2	60.3	61.9	59.4	53.6	45.9	38.7
48.0	39.5	36.8	36.7	39.3	43.9	49.5	54.3	57.2	57.3	54.6	49.8	44.4
96.0	46.5	43.9	42.2	41.7	42.6	44.7	47.4	50.0	51.9	52.3	51.4	49.3

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =47.0,BO=21.0,PC=0.64 ,D=.012

EARTH TEMPERATURE STATION OTTAWA,ONTARIO

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 47.0 ,BO= 21.C AND PO= 0.64

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	31.5	30.7	34.0	41.1	49.5	57.4	62.4	63.3	59.7	52.8	44.1	36.5
48.0	36.2	34.0	35.2	39.6	45.8	52.6	57.7	60.0	58.7	54.3	47.8	41.3
72.0	40.1	37.2	36.9	39.3	43.7	49.1	53.7	56.7	57.0	54.6	50.1	44.8
96.0	43.1	40.1	39.0	39.9	42.7	46.7	50.7	53.8	55.1	54.1	51.2	47.2
120.0	45.3	42.5	40.9	40.9	42.4	45.3	48.5	51.4	53.1	53.1	51.5	48.7
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	37.4	35.5	36.5	40.4	45.9	52.0	56.5	58.5	57.4	53.5	47.8	42.0

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	61.4	62.9	63.3	63.6	64.0
48.0	56.2	59.2	60.0	60.6	61.4
72.0	52.0	55.7	56.7	57.5	58.7
96.0	49.0	52.6	53.8	54.8	56.2
120.0	47.2	50.3	51.4	52.4	54.0
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	55.0	57.7	58.5	59.2	60.1

EARTH TEMPERATURE STATION	CORVALLIS,OREGON
TYPE OF SOIL	CLAY LOAM
TYPE OF EARTH SURFACE	UNKNOWN
DATA PROCESSED BY	
DATA SOURCE	CLIMATOLUGICAL DATA
PERICD OF OBSERVATION	1961-1962

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
2.0	40.0	44.5	46.5	54.1	58.0	70.6	78.0	75.2	65.6	54.6	45.1	40.9
4.0	40.0	43.6	45.2	52.5	54.0	68.5	75.2	74.3	65.9	54.9	45.6	41.8
8.0	38.6	43.1	43.1	50.7	54.5	66.1	72.9	72.3	63.7	53.8	44.9	40.5
20.0	44.0	46.3	46.8	53.4	56.5	65.3	72.1	73.2	68.4	60.8	52.4	45.0
40.0	46.3	46.7	46.7	50.7	53.2	59.3	62.4	67.7	66.7	62.3	55.7	49.9

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
2.0	56.0	17.9	C.56	3.3
4.0	55.0	16.9	C.64	3.6
8.0	53.6	16.4	C.65	3.0
20.0	57.0	14.5	0.81	2.4
40.0	55.7	10.7	1.13	1.7

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
2.0	38.5	40.6	46.4	55.2	63.9	70.8	73.5	71.5	65.2	56.7	47.7	41.2
4.0	39.0	40.8	46.3	54.7	63.3	70.1	72.9	71.3	65.4	57.1	48.3	41.9
8.0	40.1	41.3	46.1	53.9	62.0	68.7	71.9	70.8	65.6	58.0	49.6	43.2
20.0	43.0	42.9	46.0	51.9	58.8	65.2	68.9	69.2	65.8	59.9	52.8	46.8
40.0	47.5	45.9	46.9	50.3	55.2	60.5	64.4	66.1	65.0	61.6	56.5	51.4

(*) BASIC PARAMETERS USE FOR THE CALCULATION

A =56.0,BO=18.0,PC=0.53 ,C=.012

EARTH TEMPERATURE STATION CORVALLIS,OREGON

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 56.0 ,BO= 18.0 AND PO= 0.53

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	42.2	42.4	45.9	52.4	59.6	66.1	69.7	69.6	65.8	59.5	52.0	45.8
48.0	46.1	44.9	46.4	50.7	56.2	61.9	65.8	67.1	65.4	61.2	55.5	50.1
72.0	49.4	47.4	47.6	50.1	.1	58.7	62.5	64.6	64.3	61.8	57.7	53.2
96.0	52.0	49.7	49.1	50.3	[illegible]	56.5	59.8	62.2	62.9	61.7	58.9	55.4
120.0	54.0	51.8	50.7	50.7	52.[illegible]	55.1	57.9	60.2	61.4	61.1	59.4	56.8
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	47.2	46.1	47.5	51.3	56.2	61.2	64.7	65.9	64.4	60.7	55.6	50.7

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	68.2	69.4	69.6	69.8	70.1
48.0	64.2	66.5	67.1	67.6	68.2
72.0	60.7	63.7	64.6	65.2	66.2
96.0	58.1	61.2	62.2	63.0	64.2
120.0	56.5	59.2	60.2	61.0	62.3
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	63.0	65.3	65.9	66.4	67.2

EARTH TEMPERATURE STATION	PENDLETON,OREGON
TYPE OF SOIL	LIGHT SOIL
TYPE OF EARTH SURFACE	THIN GRASS
DATA PROCESSED BY	E.M.FITTON
DATA SOURCE	REFERENCE(4)
PERIOD OF OBSERVATION	1950

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
4.0	26.7	37.3	44.9	62.2	72.3	74.2	84.6	83.3	73.2	57.4	45.8	40.9
8.0	27.8	36.6	40.9	55.3	66.3	68.4	77.6	75.8	66.5	53.7	43.2	41.8
12.0	30.4	37.1	39.8	52.2	63.1	65.8	73.7	73.3	65.7	54.1	45.2	40.5
24.0	34.6	38.1	40.1	50.1	60.9	63.7	71.0	71.7	66.7	57.3	48.5	45.0

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
4.0	58.2	26.4	0.52	3.6
8.0	54.0	22.9	C.54	2.6
12.0	53.2	20.4	0.62	2.1
24.0	53.7	18.0	C.75	1.7

EARTH TEMPERATURE STATION PENDLETON,OREGON

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 53.0 ,BO= 26.0 AND PO= 0.48

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	32.9	33.6	39.2	48.8	59.2	68.3	73.0	72.4	66.4	57.0	46.3	37.6
48.0	38.3	37.0	39.6	46.0	54.1	62.1	67.5	69.0	66.1	59.8	51.5	43.8
72.0	43.0	40.5	41.1	45.0	50.9	57.5	62.8	65.5	64.8	60.9	54.8	48.4
96.0	46.8	43.8	43.1	45.0	49.0	54.2	59.0	62.2	62.9	60.9	56.7	51.7
120.0	49.8	46.6	45.2	45.8	48.3	52.1	56.1	59.3	60.8	60.2	57.6	53.8
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	40.0	38.7	41.1	46.8	54.0	61.1	65.9	67.3	64.7	59.1	51.6	44.8

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	70.5	72.0	72.4	72.7	73.0
48.0	65.0	68.2	69.0	69.7	70.5
72.0	60.0	64.3	65.5	66.4	67.7
96.0	56.3	60.8	62.2	63.3	65.0
120.0	53.9	57.9	59.3	60.5	62.3
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	63.2	66.4	67.3	68.0	69.0

EARTH TEMPERATURE STATION — CALHOUN,S.C.
TYPE OF SOIL — UNKNOWN
TYPE OF EARTH SURFACE — BARE
DATA PROCESSED BY — JEN-HU-CHANG
DATA SOURCE — REFERENCE(5)

PERIOD OF OBSERVATION — 1950-1951

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
2.0	40.0	41.0	49.4	57.3	69.2	75.1	78.1	77.2	70.8	59.0	43.7	40.4
12.0	42.6	44.1	51.4	57.7	70.6	76.8	80.2	80.7	74.7	67.1	51.9	44.0
18.0	45.8	46.6	53.5	59.1	71.6	77.5	81.3	82.0	77.3	68.1	56.6	47.4
24.0	47.3	47.0	53.5	58.1	70.6	76.5	80.6	81.2	77.6	70.4	59.0	49.6
36.0	48.7	47.8	52.7	56.4	67.5	73.1	78.2	78.8	77.0	71.1	62.1	52.8
48.0	50.4	49.2	52.6	55.6	65.0	70.4	76.2	77.3	76.6	71.6	64.2	55.9
60.0	52.9	51.2	53.4	56.3	64.1	69.4	74.7	75.9	76.6	72.8	66.7	59.3
72.0	54.7	52.4	53.7	55.9	62.5	67.9	71.9	74.3	75.3	72.8	67.7	61.6

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
2.0	58.5	20.5	0.51	2.0
12.0	61.9	19.9	0.65	1.7
18.0	64.0	18.9	0.69	1.4
24.0	64.4	17.9	0.77	1.4
36.0	63.9	16.0	0.91	1.2
48.0	63.8	14.4	1.04	0.9
60.0	64.5	12.9	1.16	0.9
72.0	64.3	11.5	1.28	0.9

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
2.0	42.4	45.5	53.1	64.1	74.7	82.7	85.6	82.6	74.4	63.8	52.8	45.2
12.0	44.5	46.3	52.5	62.1	72.0	79.9	83.4	81.7	75.1	65.7	55.6	48.0
18.0	45.7	46.9	52.3	61.2	70.5	78.4	82.2	81.2	75.3	66.7	57.0	49.5
24.0	47.0	47.5	52.2	60.3	69.2	76.9	81.0	80.5	75.5	67.5	58.4	51.0
36.0	49.3	48.9	52.2	59.0	66.8	74.1	78.6	79.1	75.5	68.9	60.8	53.8
48.0	51.5	50.3	52.6	58.0	64.9	71.7	76.3	77.7	75.2	69.9	62.7	56.2
60.0	53.6	51.8	53.1	57.4	63.4	69.6	74.2	76.2	74.7	70.5	64.3	58.3
72.0	55.5	53.3	53.8	57.1	62.2	67.8	72.3	74.7	74.1	70.8	65.6	60.1

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =64.0,BO=22.0,PC=0.49 ,D=.026

EARTH TEMPERATURE STATION CALHOUN, S.C.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 64.0 ,B0= 22.0 AND P0= 0.49

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	47.0	47.6	52.2	60.3	69.1	76.8	80.9	80.5	75.5	67.6	58.5	51.1
48.0	51.6	50.4	52.6	58.0	64.8	71.6	76.2	77.6	75.2	69.9	62.8	56.3
72.0	55.6	53.4	53.9	57.1	62.1	67.7	72.2	74.6	74.0	70.8	65.6	60.2
96.0	58.9	56.2	55.6	57.2	60.6	65.0	69.0	71.8	72.4	70.8	67.2	63.0
120.0	61.3	58.7	57.4	57.9	59.9	63.2	66.5	69.3	70.6	70.1	67.9	64.8
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	53.0	51.9	53.9	58.6	64.7	70.8	74.9	76.1	74.0	69.3	63.0	57.1

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	78.8	80.2	80.5	80.7	81.0
48.0	74.1	76.9	77.6	78.1	78.8
72.0	69.9	73.5	74.6	75.4	76.5
96.0	66.8	70.5	71.8	72.7	74.1
120.0	64.8	68.1	69.3	70.3	71.9
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	72.6	75.3	76.1	76.7	77.6

EARTH TEMPERATURE STATION	UNION, S.C.
TYPE OF SOIL	SANDY LOAM
TYPE OF EARTH SURFACE	GRASS SOD
DATA PROCESSED BY	
DATA SOURCE	CLIMATOLOGICAL DATA
PERIOD OF OBSERVATION	1960-1962

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
1.0	37.0	39.7	42.8	54.1	65.7	73.1	76.4	75.6	72.2	59.9	51.7	38.9
4.0	38.6	41.3	44.1	54.9	66.2	73.1	77.1	76.7	72.9	62.0	53.3	41.0
12.0	40.9	43.5	46.2	56.1	67.2	74.1	78.1	78.2	74.6	65.2	56.5	43.8

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
1.0	57.3	20.4	C.68	2.8
4.0	58.5	19.8	0.70	2.8
12.0	60.4	19.2	C.75	2.8

EARTH TEMPERATURE STATION UNION,S.C.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 59.0 ,BO= 20.0 AND PO= 0.67

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
	MONTH OF YEAR											
24.0	44.4	43.4	46.4	52.9	60.9	68.6	73.5	74.6	71.4	65.0	56.7	49.3
48.0	48.9	46.7	47.6	51.6	57.5	64.0	68.9	71.3	70.3	66.3	60.2	53.9
72.0	52.6	49.8	49.4	51.5	55.6	60.7	65.2	68.2	68.6	66.4	62.2	57.2
96.0	55.5	52.6	51.4	52.1	54.7	58.5	62.3	65.4	66.7	65.9	63.2	59.4
120.0	57.6	54.9	53.3	53.1	54.5	57.2	60.3	63.1	64.8	64.9	63.4	60.8
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	50.0	48.0	48.8	52.4	57.7	63.4	67.8	70.0	69.0	65.5	60.0	54.5

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	72.7	74.2	74.6	74.9	75.3
48.0	67.7	70.5	71.3	71.9	72.7
72.0	63.6	67.1	68.2	69.0	70.1
96.0	60.8	64.2	65.4	66.3	67.7
120.0	59.1	62.0	63.1	64.0	65.5
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	66.6	69.2	70.0	70.6	71.5

EARTH TEMPERATURE STATION — MADISON,S.D.
TYPE OF SOIL — SILTY CLAY
TYPE OF EARTH SURFACE — GRASS SOD
DATA PROCESSED BY
DATA SOURCE — CLIMATOLOGICAL DATA

PERIOD OF OBSERVATION — 1961-1962

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
4.0	24.6	29.2	32.4	43.7	61.2	70.0	73.2	73.4	62.6	53.2	40.7	33.5
8.0	26.6	30.5	32.9	41.6	58.9	67.7	73.0	72.4	62.8	54.0	42.2	35.9
20.0	27.9	28.2	30.3	36.1	51.1	59.4	66.0	67.0	60.6	53.4	43.4	36.1
40.0	31.7	28.8	29.1							52.0	45.0	38.6

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
4.0	50.1	24.0	C.67	2.2
8.0	50.1	22.5	0.73	2.3
20.0	46.8	19.7	C.99	1.9
40.0	42.4	13.9	1.27	0.6

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
4.0	22.8	24.5	31.7	43.5	55.3	66.2	71.1	69.6	61.8	50.2	37.5	27.7
8.0	24.5	25.4	31.6	42.3	54.0	64.1	69.3	68.7	62.0	51.5	39.5	29.8
20.0	29.5	28.3	31.9	39.7	49.2	58.4	64.3	65.7	61.8	54.2	44.3	35.5
40.0	36.6	33.6	34.0	38.0	44.2	51.4	57.2	60.4	59.9	55.9	49.4	42.5

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =47.0,BO=26.0,PC=0.59 ,D=.010

EARTH TEMPERATURE STATION MADISON, S.D.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 47.0 ,B0= 26.0 AND P0= 0.59

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	27.4	27.0	31.6	40.6	51.0	60.7	66.4	67.0	62.0	53.2	42.4	33.2
48.0	33.2	30.9	32.7	38.5	46.3	54.6	60.6	63.1	61.1	55.4	47.2	39.3
72.0	37.9	34.7	34.7	37.9	43.5	50.2	55.8	58.2	59.2	56.0	50.2	43.7
96.0	41.7	38.2	37.0	38.4	42.0	47.1	52.0	55.7	57.0	55.5	51.7	46.8
120.0	44.6	41.2	39.4	39.5	41.6	45.2	49.3	52.8	54.7	54.5	52.1	48.7
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	34.7	32.7	34.3	39.4	46.4	53.8	59.1	61.3	59.5	54.5	47.2	40.1

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	64.8	66.6	67.0	67.3	67.8
48.0	58.6	62.2	63.1	63.8	64.8
72.0	53.5	57.9	59.2	60.2	61.6
96.0	49.8	54.3	55.7	56.9	58.6
120.0	47.5	51.3	52.8	54.0	55.9
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	57.1	60.3	61.3	62.1	63.2

EARTH TEMPERATURE STATION — JACKSON, TENN.
TYPE OF SOIL — SILT LOAM
TYPE OF EARTH SURFACE — COARSE GRASS
DATA PROCESSED BY
DATA SOURCE — US WEATHER B.C.

PERIOD OF OBSERVATION — 1949-1951

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
4.0	43.3	43.8	50.6	59.8	67.6	75.6	79.0	75.8	70.1	61.3	44.7	41.1
12.0	45.2	45.1	48.0	54.7	64.5	74.3	76.6	75.2	70.1	61.5	47.3	43.1
24.0	49.1	46.8	50.7	53.8	63.8	68.8	73.1	73.4	69.8	65.1	51.6	48.3
48.0	50.5	50.1	51.3	53.7	60.2	66.0	69.7	70.4	69.6	64.6	56.8	51.7
72.0	52.1	51.4	51.4	52.2	56.8	60.9	64.1	65.8	67.3	65.0	60.1	53.8

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
4.0	59.5	19.1	0.49	3.8
12.0	58.8	17.5	0.62	3.2
24.0	59.6	13.8	0.77	2.6
48.0	59.6	10.9	0.94	1.3
72.0	58.5	8.2	1.25	1.2

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
4.0	40.9	43.8	50.7	60.6	69.9	76.9	79.2	76.2	68.8	59.3	49.6	43.0
12.0	42.4	44.4	50.2	59.0	67.8	74.7	77.6	75.7	69.4	60.8	51.8	45.2
24.0	44.7	45.5	49.8	57.2	65.0	71.8	75.2	74.6	69.9	62.7	54.6	48.1
48.0	49.1	48.1	50.1	54.9	60.9	66.9	70.8	71.9	69.7	65.0	58.8	53.1
72.0	52.8	50.9	51.3	54.1	58.3	63.2	67.1	69.1	68.7	65.9	61.4	56.7

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =60.0,B0=20.0,PC=0.44 ,D=.022

EARTH TEMPERATURE STATION JACKSON, TENN.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 60.0 ,B0= 20.0 AND PU= 0.44

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	44.4	45.3	49.8	57.4	65.4	72.2	75.5	74.7	69.8	62.5	54.2	47.8
48.0	48.5	47.7	50.0	55.1	61.4	67.4	71.4	72.3	69.8	64.8	58.3	52.5
72.0	52.1	50.3	51.0	54.1	58.7	63.8	67.8	69.7	68.9	65.8	61.0	56.1
96.0	55.0	52.8	52.4	54.1	57.2	61.3	64.8	67.2	67.6	65.9	62.6	58.7
120.0	57.3	55.0	54.0	54.6	56.5	59.5	62.6	65.0	66.0	65.4	63.3	60.4
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	49.8	47.1	51.1	55.6	61.2	66.6	70.1	70.9	68.7	64.3	58.5	53.3

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	73.4	74.5	74.7	74.9	75.2
48.0	69.3	71.7	72.3	72.7	73.4
72.0	65.5	68.8	69.7	70.4	71.3
96.0	62.7	66.1	67.2	68.0	69.3
120.0	60.8	63.9	65.0	65.9	67.3
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	67.9	70.3	70.9	71.5	72.2

EARTH TEMPERATURE STATION — TEMPLE, TEXAS
TYPE OF SOIL — ABILENE CLAY
TYPE OF EARTH SURFACE — HORTICULTURAL
DATA PROCESSED BY
DATA SOURCE — US WEATHER R.C.

PERIOD OF OBSERVATION — 1919-1924

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
1.0	50.8	53.3	59.4	68.3	79.9	85.3	92.0	92.5	84.1	72.6	58.8	53.0
3.0	50.7	52.7	58.7	67.8	79.0	84.9	90.7	92.3	83.9	71.8	58.2	52.7
6.0	51.8	53.2	58.8	64.6	78.3	83.6	89.8	90.9	83.3	71.7	61.0	53.7
12.0	52.9	53.9	58.6	65.8	75.9	83.5	87.0	88.6	83.4	73.5	62.6	55.4
24.0	55.9	55.3	58.6	64.8	72.6	78.9	83.1	87.4	82.6	75.8	65.6	58.8
36.0	58.8	57.6	59.5	64.2	70.5	76.5	80.8	83.8	82.2	77.9	69.1	62.1
48.0	55.5	58.9	60.2	63.5	67.8	74.2	78.4	81.4	81.0	77.7	70.8	64.6

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(R)	PHASE ANGLE(P)	STANDARD DEVIATION
1.0	70.9	21.1	0.60	4.2
3.0	70.4	20.9	0.61	3.9
6.0	70.1	19.8	0.67	3.9
12.0	70.2	18.2	0.71	2.9
24.0	70.0	15.6	0.86	2.7
36.0	70.3	13.2	1.02	1.9
48.0	69.6	12.1	1.12	4.0

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
1.0	49.3	51.4	58.1	68.4	78.8	87.1	90.7	88.7	81.5	71.5	60.7	52.8
3.0	49.8	51.6	57.9	67.9	78.2	86.5	90.2	88.5	81.6	71.9	61.4	53.4
6.0	50.5	52.0	57.8	67.3	77.3	85.5	89.4	88.1	81.8	72.5	62.3	54.4
12.0	52.0	52.7	57.7	66.3	75.6	83.7	87.9	87.3	82.0	73.6	64.0	56.2
24.0	54.9	54.4	57.7	64.6	72.7	80.3	85.0	85.6	82.0	75.3	66.9	59.6
36.0	57.6	55.2	58.2	63.6	70.5	77.4	82.2	83.8	81.6	76.3	69.2	62.5
48.0	60.0	58.0	59.0	63.0	68.7	75.0	79.8	82.0	80.9	76.9	71.0	64.9

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =70.0,BC=21.0,PC=0.58 ,D=.019

EARTH TEMPERATURE STATION TEMPLE, TEXAS

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 70.0 ,BO= 21.0 AND PO= 0.58

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	54.1	53.9	57.7	65.0	73.4	81.2	85.7	86.1	82.0	74.9	66.2	58.7
48.0	58.7	57.0	58.5	63.2	69.6	76.3	81.1	83.0	81.3	76.7	70.1	63.6
72.0	62.6	60.1	60.1	62.8	67.3	72.7	77.2	79.9	79.8	77.2	72.5	67.2
96.0	65.7	62.9	61.9	63.1	66.1	70.2	74.1	77.1	78.0	76.9	73.7	69.7
120.0	68.0	65.3	63.8	64.0	65.7	68.6	71.9	74.7	76.2	76.0	74.2	71.3
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	60.0	58.4	59.8	64.0	69.6	75.6	79.9	81.6	80.1	75.9	70.1	64.3

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	84.3	85.8	86.1	86.4	86.7
48.0	79.4	82.3	83.0	83.6	84.3
72.0	75.3	78.9	79.9	80.7	81.8
96.0	72.3	75.9	77.1	78.0	79.4
120.0	70.4	73.5	74.7	75.7	77.2
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	78.1	80.8	81.6	82.2	83.1

EARTH TEMPERATURE STATION	TEMPLE, TEXAS
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	UNKNOWN
DATA PROCESSED BY	E.M.FITTON
DATA SOURCE	REFERENCE(4)
PERICD OF OBSERVATION	1918-1924

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
1.0	53.1	52.6	59.4	69.1	78.8	88.6	93.7	93.2	83.8	72.6	59.8	52.6
3.0	53.2	52.3	58.6	67.9	78.3	86.5	92.2	93.3	83.9	73.1	60.2	52.8
6.0	53.3	52.7	58.7	67.5	77.3	85.6	91.7	92.3	83.8	73.3	60.9	53.4
12.0	54.6	53.5	58.1	65.9	74.9	83.4	87.8	88.9	83.8	74.8	62.9	55.4
24.0	56.9	55.?	58.2	64.8	72.1	78.9	84.2	86.9	83.6	76.3	67.0	59.5
36.0	59.6	57.4	59.0	64.2	70.2	76.4	81.7	84.4	83.3	78.7	71.0	62.9
48.0	61.1	58.9	59.0	63.6	68.7	74.0	79.2	82.2	82.1	79.2	73.2	65.0

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
1.0	71.5	21.5	0.60	1.7
3.0	71.1	21.0	C.64	1.8
6.0	?1.0	20.4	0.66	1.6
12.0	70.4	18.3	C.74	1.2
24.0	70.4	15.6	0.90	0.9
36.0	70.8	13.5	1.08	0.7
48.0	70.6	12.1	1.22	0.7

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
1.0	50.3	52.2	58.7	68.9	79.4	87.9	91.6	89.9	82.8	72.9	62.1	54.0
3.0	50.9	52.5	58.6	68.5	78.7	87.2	91.1	89.6	83.0	73.4	62.8	54.7
6.0	51.7	52.9	58.5	67.9	77.8	86.1	90.2	89.2	83.1	74.0	63.8	55.8
12.0	53.3	53.7	58.4	66.8	76.0	84.1	88.6	88.3	83.3	75.1	65.6	57.7
24.0	56.4	55.6	58.6	65.1	73.0	80.6	85.4	86.4	83.2	76.7	68.6	61.3
36.0	59.3	57.6	59.2	64.2	70.8	77.6	82.5	84.4	82.6	77.7	70.9	64.3
48.0	61.9	59.5	60.1	63.7	69.1	75.2	79.9	82.4	81.8	78.2	72.6	66.8

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =71.0,B0=21.0,P0=0.60 ,D=.016

EARTH TEMPERATURE STATION TEMPLE,TEXAS

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 71.0 ,B0= 21.0 AND P0= 0.59

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	55.2	54.9	58.6	65.8	74.3	82.1	86.7	87.2	83.1	76.0	67.3	59.8
48.0	59.8	58.0	59.5	64.1	70.5	77.2	82.0	84.0	82.4	77.8	71.2	64.7
72.0	63.7	61.1	61.1	63.7	68.2	73.6	78.1	80.9	80.9	78.3	73.6	68.3
96.0	66.7	63.9	62.9	64.1	67.0	71.1	75.1	78.0	79.1	77.9	74.8	70.8
120.0	69.0	66.3	64.8	64.9	66.6	69.6	72.8	75.7	77.2	77.0	75.2	72.4
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	61.1	59.4	60.7	64.9	70.5	76.5	80.8	82.6	81.1	77.0	71.2	65.4

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	85.3	86.8	87.2	87.4	87.8
48.0	80.4	83.2	84.0	84.6	85.3
72.0	76.2	79.8	80.9	81.7	82.8
96.0	73.2	76.9	78.0	79.0	80.4
120.0	71.4	74.5	75.7	76.6	78.2
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	79.1	81.8	82.6	83.2	84.1

EARTH TEMPERATURE STATION — SALT LAKE CITY,UTA
TYPE OF SOIL — SANDY LOAM
TYPE OF EARTH SURFACE — BARE
DATA PROCESSED BY
DATA SOURCE — CLIMATOLOGICAL DATA

PERIOD OF OBSERVATION — 1960-1962

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
4.0	30.5	33.5	39.0	52.5	60.7	67.9	71.2	69.1	60.4	51.1	40.0	32.1
8.0	31.3	33.5	38.8	51.7	59.6	67.0	70.5	69.3	60.7	52.1	41.2	33.2
20.0	32.0	34.4	38.2	49.0	56.1	63.2	67.1	67.5	60.3	53.3	43.7	36.1
39.0	37.1	35.0	39.0	47.4	55.2	60.1	64.9	66.8	61.4	55.8	46.3	40.7

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
4.0	50.8	20.6	C.51	2.6
8.0	50.8	20.0	0.55	2.5
20.0	50.2	17.5	C.66	2.3
39.0	50.8	15.3	0.81	2.1

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
4.0	30.7	33.5	40.6	51.0	61.0	68.6	71.3	68.5	60.9	50.9	40.6	33.3
8.0	31.4	33.8	40.4	50.3	60.1	67.7	70.6	68.3	61.1	51.5	41.5	34.2
20.0	33.4	34.7	40.0	48.6	57.6	65.0	68.6	67.4	61.7	53.3	44.0	36.9
39.0	36.5	36.3	39.8	46.6	54.3	61.3	65.4	65.7	61.9	55.3	47.3	40.6

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =51.0,BO=21.0,PC=0.48 ,D=.035

EARTH TEMPERATURE STATION SALT LAKE CITY,UTA

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 51.0 ,BO= 21.0 AND PO= 0.48

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	34.8	35.4	39.8	47.6	56.0	63.3	67.2	66.7	61.8	54.3	45.6	38.6
48.0	39.2	38.0	40.2	45.4	51.9	58.4	62.7	64.0	61.6	56.5	49.8	43.5
72.0	42.9	40.9	41.4	44.5	49.3	54.6	58.9	61.1	60.5	57.4	52.5	47.3
96.0	46.0	43.5	43.0	44.6	47.8	52.0	55.8	58.4	59.0	57.4	54.0	49.9
120.0	48.4	45.9	44.7	45.2	47.2	50.3	53.5	56.1	57.3	56.8	54.7	51.7
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	40.5	39.5	41.4	46.0	51.8	57.6	61.4	62.5	60.4	55.9	49.9	44.4

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	65.1	66.4	66.7	66.9	67.2
48.0	60.7	63.3	64.0	64.5	65.1
72.0	56.7	60.1	61.1	61.8	62.9
96.0	53.7	57.3	58.4	59.3	60.7
120.0	51.7	54.9	56.1	57.1	58.5
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	59.3	61.8	62.5	63.1	63.9

EARTH TEMPERATURE STATION — SALT LAKE CITY,UTA
TYPE OF SOIL — SANDY LOAM
TYPE OF EARTH SURFACE — BARE
DATA PROCESSED BY
DATA SOURCE — CLIMATOLOGICAL DATA

PERIOD OF OBSERVATION — 1960-1962

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
4.0	30.5	33.5	39.0	52.5	60.7	67.9	71.2	69.1	60.4	51.1	40.0	32.1
8.0	31.3	33.5	38.8	51.7	59.6	67.0	70.5	69.3	60.7	52.1	41.2	33.2
20.0	32.0	34.4	38.2	49.0	56.1	63.2	67.1	67.5	60.3	53.3	43.7	36.1
39.0	37.1	35.0	39.0	47.4	55.2	60.1	64.9	66.8	61.4	55.8	46.3	40.7

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
4.0	50.8	20.6	C.51	2.6
8.0	50.8	20.0	0.55	2.5
20.0	50.2	17.5	C.66	2.3
39.0	50.8	15.3	0.81	2.1

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(•)

MONTH OF YEAR

DEPTH BELOW SURFACE(IN)	J	F	M	A	M	J	J	A	S	O	N	D
4.0	30.7	33.5	40.6	51.0	61.0	68.6	71.3	68.5	60.9	50.9	40.6	33.3
8.0	31.4	33.8	40.4	50.3	60.1	67.7	70.6	68.3	61.1	51.5	41.5	34.2
20.0	33.4	34.7	40.0	48.6	57.6	65.0	68.6	67.4	61.7	53.3	44.0	36.9
39.0	36.5	36.3	39.8	46.6	54.3	61.3	65.4	65.7	61.9	55.3	47.3	40.6

(•) BASIC PARAMETERS USED FOR THE CALCULATION

A =51.0,BO=21.0,PC=0.48 ,C=.035

EARTH TEMPERATURE STATION	BURLINGTON, VT.
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	BARE
DATA PROCESSED BY	JEN-HU-CHANG
DATA SOURCE	REFERENCE(5)
PERIOD OF OBSERVATION	1951-1955

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
0.2	29.5	29.6	32.7	45.5	58.6	69.9	78.2	72.1	62.5	49.4	38.0	32.2
1.0	29.5	30.0	34.5	45.7	58.2	69.8	77.2	71.5	61.7	48.3	37.4	32.5
3.0	29.6	29.8	32.7	45.0	57.7	69.2	76.3	71.4	61.4	48.8	37.4	32.8

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
0.2	50.0	24.0	0.62	2.7
1.0	49.8	23.4	0.59	2.6
3.0	49.5	23.2	0.61	2.6

EARTH TEMPERATURE STATION BURLINGTON,VT.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 49.0 ,B0= 26.0 AND PD= 0.60

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	29.5	29.0	33.5	42.4	52.8	62.5	68.3	69.0	64.2	55.4	44.6	35.3
48.0	35.2	32.9	34.6	40.4	48.2	56.5	62.5	65.1	63.2	57.5	49.4	41.4
72.0	40.0	36.8	36.7	39.9	45.4	52.1	57.7	61.2	61.3	58.1	52.3	45.8
96.0	43.8	40.3	39.0	40.4	44.0	49.0	54.0	57.7	59.0	57.6	53.8	48.9
120.0	46.6	43.7	41.4	41.5	43.5	47.2	51.2	54.7	56.7	56.5	54.3	50.8
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	36.8	34.7	36.2	41.3	48.3	55.7	61.0	63.3	61.6	56.6	49.4	42.2

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	66.8	68.6	69.0	69.2	69.8
48.0	60.6	64.2	65.1	65.8	66.8
72.0	55.4	59.9	61.2	62.2	63.6
96.0	51.7	56.2	57.7	58.8	60.6
120.0	49.5	53.2	54.7	55.9	57.8
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	59.0	62.3	63.3	64.1	65.2

EARTH TEMPERATURE STATION	PULLMAN, WASH.
TYPE OF SOIL	SILTY LOAM
TYPE OF EARTH SURFACE	VEGETATION
DATA PROCESSED BY	JEN-HU-CHANG
DATA SOURCE	REFERENCE(5)
PERIOD OF OBSERVATION	1943-1951

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR											
	J	F	M	A	M	J	J	A	S	O	N	D
1.0	33.7	33.4	38.3	50.1	65.1	74.6	86.1	84.5	75.2	58.5	43.0	36.4
6.0	36.8	37.5	41.5	51.6	60.1	68.7	75.5	75.7	67.5	55.8	44.1	40.2

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
1.0	56.7	26.9	C.69	2.8
6.0	54.7	19.8	0.67	1.9

EARTH TEMPERATURE STATION PULLMAN, WASH.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 48.0 ,BO= 22.0 AND PO= 0.60

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	31.5	31.1	34.9	42.4	51.3	59.5	64.4	65.0	60.8	53.4	44.3	36.4
48.0	36.4	34.4	35.9	40.7	47.3	54.3	59.5	61.6	60.0	55.2	48.3	41.6
72.0	40.4	37.7	37.6	40.3	44.9	50.6	55.4	58.3	58.4	55.7	50.8	45.3
96.0	43.6	40.6	39.6	40.7	43.7	48.0	52.2	55.3	56.4	55.3	52.1	47.9
120.0	46.0	43.1	41.6	41.6	43.4	45.5	49.8	52.8	54.5	5[illegible].4	52.5	4[illegible].5
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	37.6	35.9	37.2	41.5	47.4	53.6	58.2	60.[illegible]	58.7	54.4	48.3	42.3

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	63.0	64.6	65.0	65.2	65.6
48.0	57.8	60.9	61.6	62.2	63.0
72.0	53.4	57.2	58.3	59.2	60.4
96.0	50.3	54.1	55.3	56.3	57.8
120.0	48.4	51.6	52.8	53.9	55.5
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	56.5	59.3	60.1	60.8	61.7

EARTH TEMPERATURE STATION	PULLMAN, WASH.
TYPE OF SOIL	UNKNOWN
TYPE OF EARTH SURFACE	BLUE GRASS SOD
DATA PROCESSED BY	F.P.FITTON
DATA SOURCE	REFERENCE(4)
PERIOD OF OBSERVATION	1912-1913

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
1.0	31.7			46.5	60.2	62.7	66.0	75.4	60.2	42.0	40.0	33.2
2.0	31.9			45.4	57.8	63.2	65.9	73.2	58.9	42.0	39.9	33.7
6.0	32.3			44.7	54.9	62.3	64.8	70.2	57.2	42.4	40.4	34.5
12.0	32.7			44.8	52.8	62.2	64.9	67.7	56.7	45.0	42.2	36.0
24.0	35.6			44.3	50.6	59.0	62.8	66.5	58.5	48.5	45.0	39.2
36.0	37.5			44.1	48.9	56.3	60.9	64.8	58.9	50.9	47.4	41.9

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
1.0	49.1	19.8	0.55	4.9
2.0	48.5	19.2	0.56	4.3
6.0	47.8	17.8	0.58	3.7
12.0	48.0	16.8	0.63	2.8
24.0	48.6	14.7	0.78	2.2
36.0	48.9	13.0	0.92	1.8

EARTH TEMPERATURE STATION PULLMAN,WASH.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 48.0 ,B0= 19.0 AND P0= 0.50

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	33.4	33.8	37.7	44.6	52.3	59.0	62.6	62.3	58.0	51.2	43.4	37.0
48.0	37..	36.3	38.1	42.7	48.6	54.5	58.5	59.7	57.7	53.2	47.1	41.4
72.0	40.8	38.9	39.2	42.0	46.3	51.1	55.0	57.1	56.7	54.0	49.5	44.8
96.0	43.6	41.3	40.7	42.1	45.0	48.8	52.2	54.7	55.2	53.9	50.9	47.2
120.0	45.7	43.4	42.3	42.7	44.4	47.2	50.1	52.5	53.7	53.3	51.4	48.7
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	38.6	37.6	39.2	43.3	48.5	53.8	57.3	58.4	56.7	52.6	47.2	42.2

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES
AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	60.8	62.0	62.3	62.5	62.8
48.0	56.7	59.1	59.7	60.2	60.8
72.0	53.1	56.2	57.1	57.8	58.8
96.0	50.3	53.6	54.7	55.5	56.7
120.0	48.6	51.5	52.5	53.4	54.8
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	55.5	57.8	58.4	59.0	59.7

EARTH TEMPERATURE STATION	SEATTLE, WASH.
TYPE OF SOIL	SAND OVER CLAY
TYPE OF EARTH SURFACE	BLUE GRASS
DATA PROCESSED BY	JEN-HU-CHANG
DATA SOURCE	REFERENCE(5)
PERIOD OF OBSERVATION	1948-1950

OBSERVED MONTHLY AVERAGE EARTH TEMPERATURES

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
19.7	38.9	39.6	45.4	49.7	55.7	60.4	62.8	64.3	61.9	55.3	50.1	45.0
49.2	43.9	41.9	45.7	48.4	52.0	55.4	59.9	61.2	55.7	56.9	53.2	49.1
88.6	48.3	45.1	46.5	48.9	50.9	52.6	56.0	57.7	58.2	56.7	54.1	51.8
128.0	51.2	48.7	48.1	49.3	54.7	51.5	54.1	60.6	56.3	55.8	54.1	53.0
167.3	52.9	51.3	50.2	50.6	51.0	51.4	53.5	55.0	56.1	56.0	54.9	54.2
206.7	52.3	52.4	51.7	51.2	51.2	51.3	52.8	53.9	54.5	54.7	54.1	53.9

RESULTS OF LEAST SQUARES ANALYSIS

DEPTH BELOW SURFACE(IN)	AVERAGE(A)	AMPLITUDE(B)	PHASE ANGLE(P)	STANDARD DEVIATION
19.7	52.5	12.1	0.79	1.2
49.2	52.0	8.2	1.04	1.6
88.6	52.2	6.0	1.37	0.7
128.0	53.1	4.3	1.40	1.9
167.3	53.1	2.9	1.95	0.3
206.7	52.8	1.8	2.14	0.4

CALCULATED EARTH TEMPERATURES AT OBSERVED DEPTHS(*)

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
19.7	40.8	40.7	43.6	49.3	55.8	61.7	65.1	65.3	62.1	56.6	49.9	44.2
49.2	44.5	43.1	44.3	47.9	52.7	57.8	61.4	62.9	61.6	58.1	53.0	48.2
88.6	48.4	46.4	46.0	47.6	50.5	54.2	57.5	59.6	59.9	58.4	55.3	51.8
128.0	51.1	49.1	48.0	48.3	49.7	52.2	54.7	56.9	58.0	57.7	56.2	53.8
167.3	52.9	51.1	49.9	49.4	49.9	51.3	53.1	54.9	56.2	56.6	56.1	54.7
206.7	53.7	52.4	51.3	50.5	50.5	51.1	52.2	53.5	54.8	55.5	55.5	54.9

(*) BASIC PARAMETERS USED FOR THE CALCULATION

A =53.0, AO=15.0, PC=0.64 , D=.034

EARTH TEMPERATURE STATION SEATTLE, WASH.

CALCULATED EARTH TEMPERATURES AT SELECTED DEPTHS
FOR DIFFUSIVITY=0.025, A= 53.0 ,B0= 15.0 AND PO= 0.64

DEPTH BELOW SURFACE(IN)	MONTH OF YEAR J	F	M	A	M	J	J	A	S	O	N	D
24.0	41.9	41.4	43.7	48.8	54.8	60.4	64.0	64.7	62.1	57.1	50.9	45.5
48.0	45.3	43.7	44.6	47.7	52.2	57.0	60.6	62.3	61.3	58.2	53.6	48.9
72.0	48.0	46.0	45.8	47.5	50.6	54.5	57.8	59.9	60.1	58.4	55.2	51.5
96.0	50.2	48.1	47.3	47.9	49.9	52.8	55.7	57.9	58.8	58.1	56.0	53.2
120.0	51.8	49.8	48.7	48.6	49.7	51.8	54.1	56.2	57.4	57.4	56.2	54.2
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	46.1	44.8	45.5	48.3	52.2	56.5	59.8	61.2	60.4	57.7	53.5	49.4

CALCULATED AUGUST EARTH TEMPERATURE AT SELECTED DIFFUSIVITIES AND SELECTED DEPTHS

DEPTH BELOW SURFACE(IN)	DIFFUSIVITIES 0.010	0.020	0.025	0.030	0.040
24.0	63.3	64.4	64.7	64.9	65.1
48.0	59.6	61.7	62.3	62.7	63.3
72.0	56.6	59.2	59.9	60.5	61.4
96.0	54.5	57.0	57.9	58.6	59.6
120.0	53.2	55.3	56.2	56.9	58.0
INTEGRATED AVERAGE FROM SURFACE TO 10 FT.	58.7	60.7	61.2	61.7	62.4